RNI: DELENG/2005/15153
Publication: 15th of every month
Posting: 19th/20th of every month at NDPSO

No: DL(E)-01/5079/17-19
Licensed to post without pre-payment U(E) 28/2017-19
Rs.150

ISSN 0973-2136

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Coordinates

Volume XIV, Issue 1, January 2018

THE MONTHLY MAGAZINE ON POSITIONING, NAVIGATION AND BEYOND

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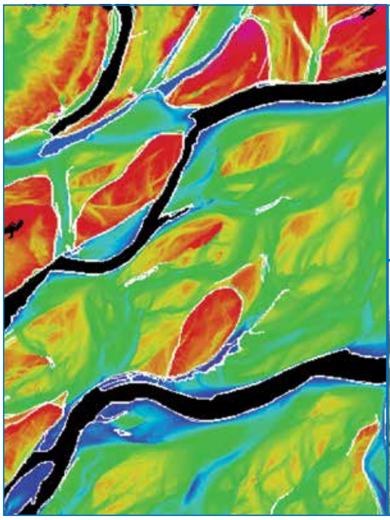


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This issue has been made possible by the support and good wishes of the following individuals and companies
Belkacem Benadda, Christian Sevcik, Ivan G Petrovski, Jean-Christophe Zufferey, Jean-François Baudet, Jingnong Weng, John Fischer, Lahouaria Tabti, Mark Sampson, Mia Flić, PVSSN Gopala Krishna, Renato Filjar, Ron Bisio, Salem Kahlouche and Thibault Bonnevie and V Raghu Venkataraman and; Geomax, FOIF, IP Solutions, Javad, Labsat, MicroSurvey, Pentax, Riegl, SBG System, and many others.

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[subscriptions] iwant@mycoordinates.org
Web www.mycoordinates.org

Annual subscription (12 issues)
[India] Rs.1,800 [Overseas] US$100

Printed and published by Sanjay Malaviya on behalf of Coordinates Media Pvt Ltd
Published at A 002 Mansara Apartments, Vasundhara Enclave, Delhi 110096, India.
Printed at Thomson Press (India) Ltd, Mathura Road, Faridabad, India

Editor Bal Krishna
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This issue of Coordinates is of 52 pages, including cover.


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Simulator, modeling reality, ...

Robust positioning, real-time kinetics, accurate 3D maps

Internet of Things, virtual reality, …

Interference, jamming, spoofing…

Sensor fusion, …

Disruption is a new paradigm

For Innovations

Bal Krishna, Editor
bal@mycoordinates.org

High Resolution Topography database generation using Airborne LiDAR

National Remote Sensing Centre (NRSC), ISRO, Hyderabad, India has generated High resolution Digital Elevation Model (DEM) for various river beds of the country (66,000 sq. km) with an accuracy of 25 cm in height with 2D GIS database generation compatible to 1:5000 scale. DEM generation for 25,000 sq. km area of Brahmaputra river basin is an achievement

V Raghu Venkataraman
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PVSSN Gopala Krishna
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Of late, efficient management of disasters is receiving utmost attention of the Governments. Flood is a major disaster in India and an average of 18.6 million hectares of land is affected annually in India, by floods. Disaster Management Support programme taken up by ISRO/DOS, provides timely support and services from aero-space systems, both imaging and communications, towards efficient management of disasters in the country. Decision Support Centre (DSC) established at National Remote Sensing Centre (NRSC) in 2002 under the ISRO Disaster Management Support Programme (DMSP) keeps a continuous watch on the flood situation in the country using the ground, aerial and space technologies.

The effect of floods can be minimized by proper management measures. Flood modeling requires accurate height information in Mean Sea Level (MSL) datum related to various aspects of rivers and floodplains. The terrain undulations in flood prone areas typically vary from 2m to 5m over a river bed hence, the inundation can run into huge extent of areas with a small amount of raise in flood water level. The efficient technology used to derive this information is from Airborne Laser Scanner (ALS) which gives very accurate Digital Elevation Model (DEM) up to a few tens of centimeters.

Airborne LiDAR

Airborne LiDAR system consists of airborne segment and ground segment. The airborne segment includes airborne platform, Ranging instrument and Position and Orientation System (POS) where as the ground system is comprised of GPS reference stations and Processing hardware and software for data synchronization and registration.

All laser-ranging operations are based on laser range finder that can measure distance to higher degree of accuracy. The system basically consists of an emitting diode that produces a Laser beam at a very specific wavelength in the near infrared region. The signal is sent towards earth where it is reflected off a feature back towards the aircraft. A receiver then captures the return pulse. Using very accurate timing mechanism with a typical accuracy in the order of 0.05 - 0.2 ns and knowing the speed of light, distance (Range) to the feature will be measured with an accuracy of one to two cm. In pulse mode method, two-way travel time of high intense short duration laser pulse between laser source and object is used for accurate estimation of range.

Range(R) = Velocity (V) X Time (T)/2

The accuracy with which measurements can be taken is of the order of 10 to 15 cm in elevation with dense points of upto 5 to 10 points/sq. m.

Airborne LiDAR error budget

Error category	Error order	Typical error in Z (cm)
Range	0.1 ns	3
Position (GPS)	Z cm	5 – 10*
Angular (IMU)	0.005 deg (roll)	8
Misalignment	0.0001 (rad)	9
Atmosphere		1
Terrain	plain	0
RSS of Z		**13.4 – 15.9**
* This is an indicative figure but will change with GPS solution accuracy which may vary from 5 to 10 cm.		

Table 1: Error budget of ALS50 LiDAR system

Multiple Echo

Airborne LiDAR signal also has the ability to reflect off multiple targets in its line of sight, which is most commonly observed in forest areas. The gaps between the leaves and branches allow the pulse to transmit through and reflect off obstructed upper layer while remaining pulse transmits further and reflect from lower obstructed layers including ground surface. Hence, each transmitted pulse has multiple echo system. This feature allows making measurements of the ground surface in forest areas, provides beneficial when compared to DEM generation using optical sensors.

Airborne LiDAR system for DMSP

Airborne LiDAR system is non-imaging sensor system hence it is integrated with Medium Format Digital Camera (MFDC). The combined system provides cost and time effective solution for the generation of close contours along with GIS compatible 2D spatial data. By modeling the flood inundation and estimate, monitoring floods, close contour information (0.5 m to 1.0 m) for large areas is required as database.

National remote Sensing Centre (NRSC)/Dept. of Space acquired Airborne LiDAR system integrated with Medium Format Digital Camera in 2004, for its efficiency in giving cost and time effective solution for the generation of close contours. Three models of LiDAR systems of M/s Leica Geosystems are used in the entire project life cycle (i) ALS-50 with Enerqust DC (ii) ALS50-II with RCD 105 DC and (iii) ALS-70HP with RCD 30 DC.

Floodplains area coverage

Priority areas covering approximately 60,000 sq. km. of river bed pertaining to Mahanadi, Ganga, Brahmaputra and Godavari are identified in July 2007 to take up Airborne LiDAR -DC survey for generating unique and high-resolution geospatial database. The products generated include 0.25 m he accuracy DEM in MSL, 0.5 m contours, 0.5m ortho photos and geo-database compatible to1:5000 scale.

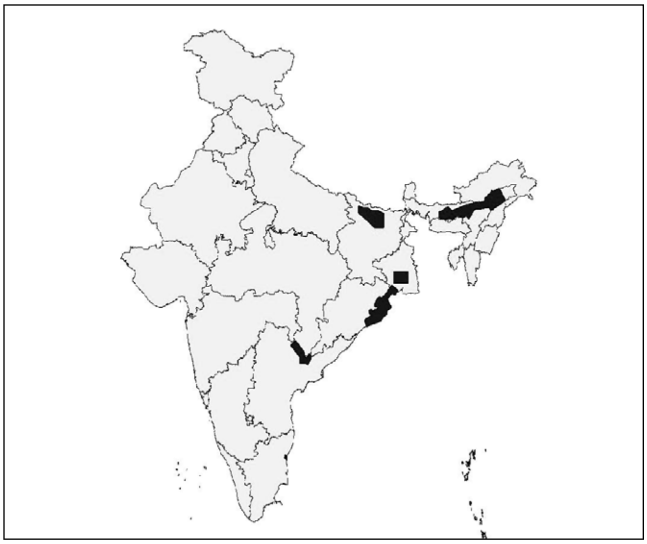

Figure 1: Areas of coverage

Project execution

The work was carried out by initially identifying the area, flight planning for all the areas (both for LIDAR and digital camera, simultaneous data collection from aircraft and ground, preprocessing, post processing, geoid estimation, output product generation and QC. The flow chart shows the LiDAR / DC process flow from flight planning to final deliverables for a typical DMSP project:

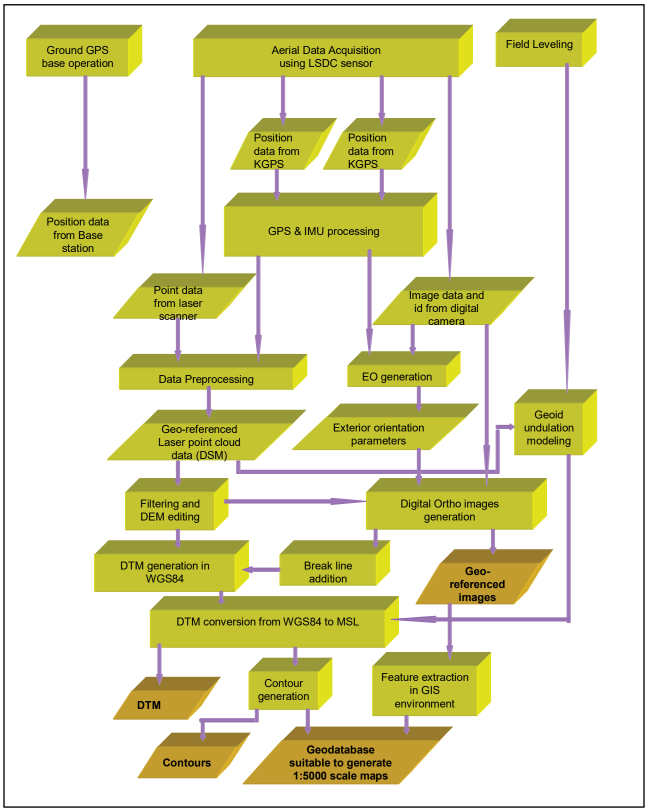

Figure 2: flowchart of various stages of project execution

Data acquisition

Flight planning

The flight planning stage is crucial which considers the accuracy and outputs required along with the type of terrain, aircraft endurance, height of flying, distances from the GPS base station. The flight lines are generated for optimum utilization of aircraft flying.

GPS Base stations

During data acquisition, DGPS base stations have been operated simultaneously in the range of 25 km of aircraft flying to improve the accuracy of the aircraft trajectory generated. Movement of field parties were planned very carefully and executed to synchronize with the aircraft operations. Added to that, field teams were kept ready in alternate area for data acquisitions in case of clouds or any other operational reasons. Field teams sometimes have to face hostile conditions such as social problems, law and order problems, local resistance etc. Subsequent to completing some areas, later on the GPS baseline lengths were increased to 50 km after studying the achieved accuracies within the flying zone thereby reducing ground survey load and acquiring data at a continuous stretch for longer distances.

Table 2 gives the number of GPS base stations operated during Data acquisition.

Sl. No	State	River / Basin	No of base stations
1	Orissa Phase-1	Mahanadi	4
2	Andhra Pradesh	Sabari (Godavari)	1
3	Bihar	Ganga	4
4	Assam Phase-1	Brahmaputra	4
5	Andhra Pradesh	Godavari	2
6	Orissa Phase-2	Mahanadi	5
7	Assam Phase-2	Brahmaputra	5
8	West Bengal	Ganga	3

Table 2 : No of base stations operated for each area

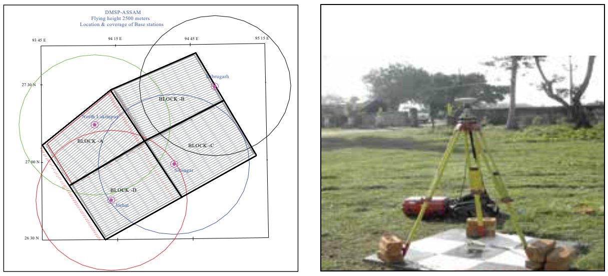

Figure 3 : Typical reference station coverage for DMSP Assam Ph 1 area

Aircraft operations

Aircraft operations are the most constrained part of Airborne LiDAR data collection cycle. Ministry of Defense (MOD) clearances, NOTAM for aircraft flying, timings of airfield operation, aircraft serviceability, proximity of the base to the survey area, pilots availability, availability of security officer, instrument serviceability, aircraft serviceability, area clearance, restricted areas falling in the data acquisition zone, no fly zones, time constraints in operating sensor and weather are some of the constraints that restrict productivity. Synchronization with the ground team, and if required, switching to the alternate area depending on local weather and cloud conditions were done to increase productivity. Immediately after completing the data acquisition, field checking of the data was carried out to assess the quality of acquisition and coverage. Re-flying was attempted to cover the gaps, if any.

Aerial data acquisition of 66239 sq. km in the above mentioned river basins is completed by December 2014. The areas worked out as 16,000 sq. km of Mahanadi basin (Orissa), 25,000 sq. km of Brahmaputra basin (Assam), 18,500 sq. km of Ganga basin (Bihar and West Bengal) and 6000 sq. km of Godavari basin (Andhra Pradesh). A small part of the area was flown with Large Format Digital Camera (LFDC) as there were sensor problems. Approximate number of hours flown for this task to cover this entire area is 571 hrs.

Sl. No	State	River / Basin	Sensor	No. of Blocks	Total No. of Lines	Total line Length (km)	Flying height (m)	Data acquisition	No of flying hours (approx)
1	Orissa Phase-1	Mahanadi	ALS50	6	185	7551	2000	2007-08	60
2	Andhra Pradesh	Sabari (Godavari)	ALS50	1	21	1043	2000	2007-08	8
3	Bihar	Ganga	ALS50	3	191	8358	2500	2009-10	118
4	Assam Phase-1	Brahmaputra	ALS50	4	114	6670	2500	2009-10	86
5	Andhra Pradesh	Godavari	LFDC	2	42	2606	3380	2011-12	62
6	Orissa Phase-2	Mahanadi	LFDC	1	25	1936	3155	2012-13	60
			ALS50-II	1	77	3697	2500	2012-13	
7	Assam Phase-2	Brahmaputra	ALS50-II	5	192	11795	2500	2013-14	157
8	West Bengal	Ganga	ALS70	1	60	4044	2500	2014-15	20

Table 3 : Data Acquisition parameters

Data pre-processing and point cloud generation

Once data reaches the processing lab, preliminary checking was carried out to ascertain complete coverage and noise free data.

LIDAR system records line-of-sight ranges referenced to the system coordinate system, POS system logs GPS data including carrier phase information and orientation data of IMU. Pre-processing involves computing raw laser Digital Surface Model (DSM) by integrating RAW Laser data with GPS and IMU data set which are time tagged accurately.

Post-processing of airborne GPS data in differential mode with the base data improved the kinematic trajectory of the aircraft in WGS84 coordinate system to an accuracy of 5-10 cm. Differential GPS solution is blended with IMU data for obtaining Smoothed Best Estimated Trajectory (SBET) of the aircraft i.e., position and orientation of the laser scanner. Linear off-sets (lever arms) between GPS and IMU (lever arms) also applied in the solution.

The GPS time tagged laser ranging data and pulse direction which is originally recorded in LIDAR coordinate system are synchronized with POS (SBET) data and transformed each ground sample point into WGS84 earth fixed coordinate system. Post processing software uses factory calibrated information along with off-sets and misalignment angles between laser scanning system atmosphere model, and IMU for deriving point cloud in X, Y, Z for each laser pulse in WGS-84 coordinate system.

Post processing

During the preprocessing stage, the accuracy of the points is determined. The post processing to generate the products such as DEM, orthophoto and geodatabase is largely manual, laborious and time consuming. Industry support was taken to for this task.

LIDAR Classification

LiDAR classification is carried out to derive bare earth (only ground points) from LiDAR point cloud by removing the outliers and off terrain points like buildings, vegetation. The bare earth extraction is implemented through automatic and manual methods. The automatic method classifies point cloud as "ground" or "non-ground" through an automatic iterative classification algorithm and manual method is carried out to verify the correctness of the automatic classification by taking into consideration the omissions and the commissions of the process.

The terrain pertaining to the project is plain to gently undulating and it is covered with settlements, sparse bushes, water bodies such as canals, water channels, well spread ponds, rivers etc. Water bodies, river etc., create natural voids in the LiDAR datasets. Voids are also created due to non-penetration of LIDAR data to the ground in dense vegetation areas.

The complete LiDAR point cloud is DSM whereas the Digital Elevation Model (DEM) generated after filtering process.

Breaklines

The breaklines are added to represent sudden variation in elevation of the ground. 3D breaklines are obtained by assigning the z-values to the 2D breaklines using the elevation data.

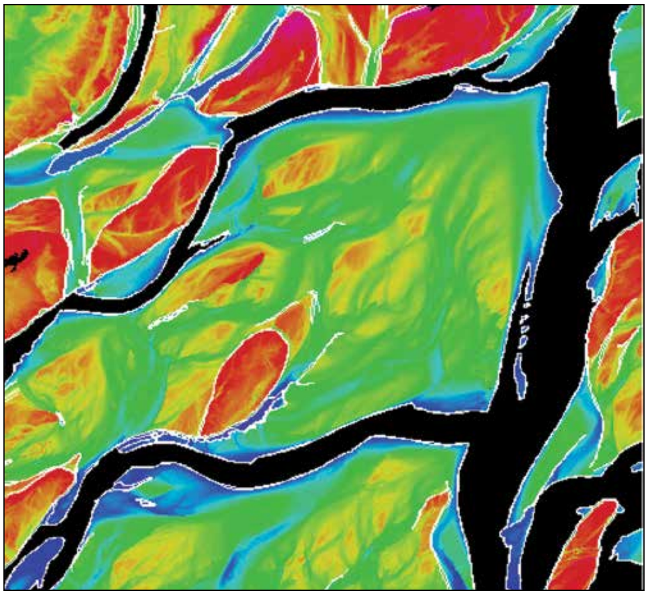

Figure 5 : Breaklines depicted in white colour

Geoid estimation:

LiDAR data is acquired in WGS84 datum. To convert these heights into MSL datum, local geoidal undulation modeling was carried out by collecting data by field methods.

Field Geoid

The heights measured by the LiDAR are ellipsoidal heights measured with reference to the WGS-84 elliposid. For any hydrological applications heights are required with reference to mean sea level i.e., orthometric heights. The ellipsoidal height, orthometric height (height with reference to Mean Sea Level: MSL) and geoidal undulations are related by the following formula

$h = H + N$

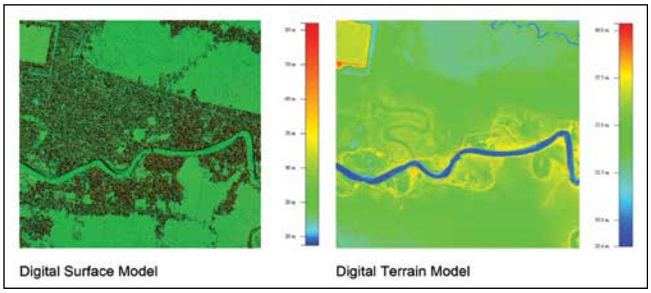

Figure 4 : Sample Digital Surface Model & Digital Terrain Model

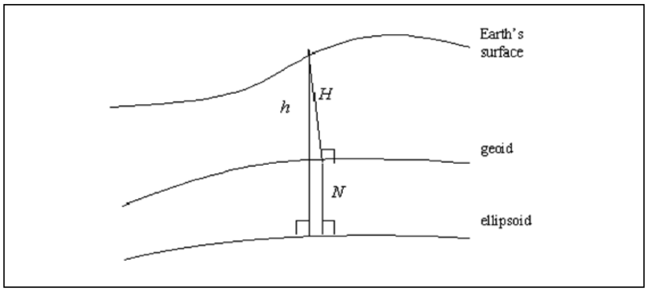

Figure 6 : Relationship between Geoid, Ellipsoid and Geoidal undulation

Local Geoid undulation surface generation

An inhouse methodology was developed to generate local geoid undulation model specific to project area.

Ground leveling data was acquired by collecting MSL for every 5 to 10 km at well distributed locations (by traversing from nearest Survey of India Bench Mark) on the ground by leveling. This is a laborious process in the sense that physically, on has to walk through the entire area and collect data. There are social and local problems associated with it. MSL heights by leveling are field collected and for the corresponding points the Ellipsoidal heights are derived by revisited in the lab from LiDAR bare earth surface.

A "locally best fitting Geoid model" is obtained by using these points. The model is validated using check points which have not been used in the transformation process. Kriging technique, a statistical interpolation technique, is used to estimate geoidal undulation values for the project area.

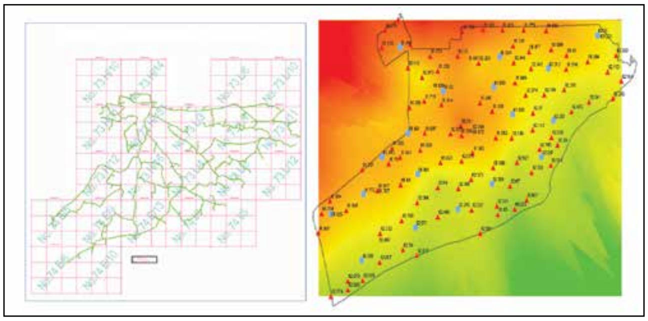

Figure 7 : DT Leveling Survey and check point distribution of for DMSP-Orissa Phase 1 (Mahanadi basin) area

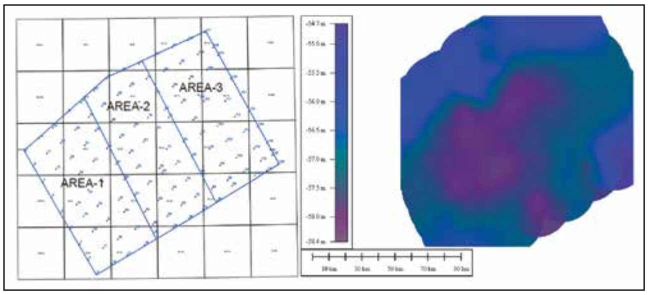

Figure 8 : Leveling points and corresponding Geoid Undulation (N) derived from field leveling for DMSP-ASSAM Phase-I (Brahmaputra) area

MSL datum conversion and DTM Generation

The LIDAR ground points in WGS-84 are adjusted with modeled geoidal undulation values to derive DTM with respect to MSL. The LiDAR points (in MSL) together with breakline data is used to generate Digital Terrain Model (DTM). The DTMs are generated in ASCII, GEOTIFF and LAS formats.

Contour Generation

Contours with 0.5m interval were generated using the bare earth DTM and breaklines. the requirement of the project is to generate 0.5m interval contours, every 5th contour (every 2.5m) is an index contour.

Orthophoto Generation

An unrectified aerial photograph will not show features in their correct locations due to displacements caused by the tilt of the sensor and by the relief in terrain. Ortho rectification transforms the central projection of the image into an orthogonal view of the ground, thereby removing the distorting effects of tilt and terrain relief. Generation of orthoimage uses DTM from filtered Airborne LiDAR data, images collected by Digital camera, exterior orientation parameters from GPS and IMU and interior orientation parameters from the factory calibration report of camera.

2D mapping

The 2D mapping is carried out for the entire area in the GIS environment using orthoimages.

A standardized 68 layers for the project is created with layer names, colour, line weight etc. Each tile of map covers 4Km X 4Km area.

Deliverables

All the data is delivered as 4Km X 4Km standard tiles in UTM projection with X, Y in WGS84 and Z in MSL. 3D geospatial database for entire area is prepared from Airborne LiDAR-DC data. This data consists of DEM in 5m X 5m grid, contours in 0.5 m interval, Orthoimage and Planimetric data. A map template consisting of graticules, north arrow, scale, legend, index etc., is standardized for all DMSP projects.

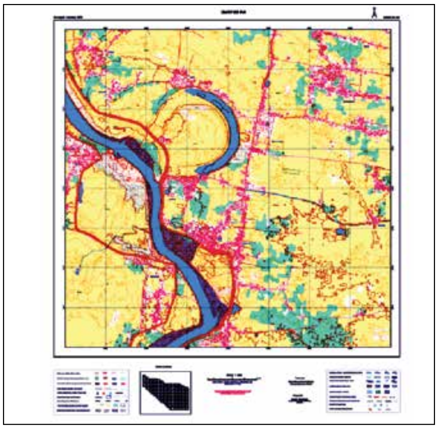

Figure 9: Sample topographic map at 1:5000 scale

Accuracy

Quality checking and control:

The Quality Assurance / Quality Control refer to the aggregate of activities that aims at ensuring that the end product of a production process meets quality requirements of the project. The quality control for LIDAR-DC project of Disaster Management Support Programme (DMSP) is a critical component in meeting project objectives and specifications. Huge volumes of LIDAR/ Digital camera data are processed and hence stringent QC procedures are indispensable in meeting project requirements.

The quality control is implemented in two parts i.e., In-process QC and Final QC. The In-process QC is done during course of production and at end of each stage of the production activity and final QC is carried out at the end product/deliverable stage and certified by QC before submitting to the end user.

Data Accuracy Evaluation

The vertical accuracy of the field geoid and Digital Terrain Model (DTM) has been validated using the well distributed check points. The table summarizes the results of the data evaluation for vertical accuracy.

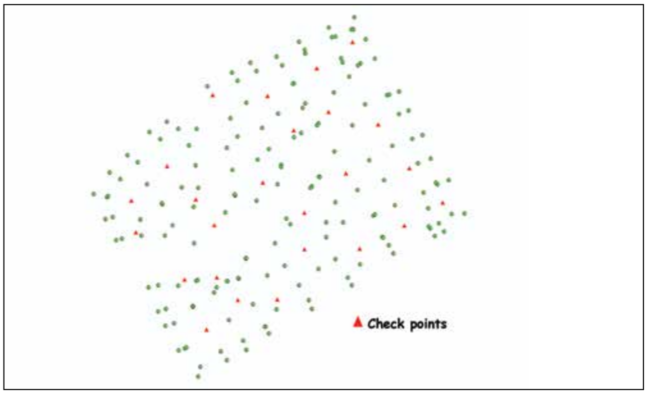

Figure 10 : Distribution of Check Points for Assam Phase 1 (Brahmaputra) area

The check point accuracies achieved for some of the projects is listed in table 4.

Sl. No	Area	No of points collected	No of check points	Standard Deviation
1	Orissa Phase 1	121	18	0.166
2	Bihar	119	25	0.2381
3	Assam ph 1	126	24	0.168

Table 4 : Standard deviation achieved with respect to check points

Conclusions

High resolution DEM with MSL heights and maps were generated using Airborne Laser Scanner – Digital camera system having an accuracy of 0.25m in height. Geo-database was also collected using 0.5m GSD ortho photos generated using Medium format Digital camera (MFDC) which is associated with the ALS system. An extent of 66,000 sq. km database was collected for the river beds pertaining to Mahanadi, Ganga, Brahmaputra and Godavari in the states of Orissa, Assam, Bihar, West Bengal and Andhra Pradesh which is serves as a base data for flood and other disaster related applications. Real time flood inundation modeling can be generated using this database by supplementing with other information. This is a unique project first time in India covering such a large extent of area with high accuracy, serves to predict flood extent and save precious human life by providing early warning, in particular to Brahmaputra river basin of Assam state.

Another 77,000 sq. km project is being taken up as phase II of this project under DMSP of ISRO/DOS covering other themes such as landslides, urban floods as well.

Acknowledgements

The authors acknowledge the support provided by the present Director of NRSC, Dr YVN Krishna Murthy and former directors Dr V K Dhadwal, Dr V Jayaraman, Dr RR Navalgund and Dr K Radhakrishnan. The support of Dr V S Hegde, former director EOS/DOS, Shri K. Kalyanaraman, former GM, AS&DM and Dr V Bhanumurthy, AD, NRSC are duly acknowledged. The direction provided by the decision making team of Sri P Srinivasulu, GD, AS&DMG, Dr S MuraliKrishnan, Head, DP&VASD, Dr G Varaprasad, Head, AO&ASD and Sri B Laxman, Manager, PP&CC are acknowledged. The authors acknowledge the contributions made by Shri K Venkateswar Rao, Manager, AS&AO and Shri S Madhusudhan Reddy, Dy Manager, Aircraft Maintenance during aircraft operations.

The Aircraft operations, Data acquisition, LiDAR Data processing, Ground surveys, Flight planning, Quality Assurance, Project planning and coordination, and budget teams from Aerial Services & Digital Mapping area are part of this work and their immense contributions are acknowledged.

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Technology trends and innovation challenges

We are in an amazing time of technology evolution! In this feature, industry stalwarts from diverse technology domain capture the trends and share their perspectives on challenges ahead...

The next wave of geospatial innovation

Ron Bisio
Vice President of Geospatial, Trimble

The geospatial profession is evolving. As seen in other industries, the next wave of geospatial technology innovation will be shaped by big data, cloud computing, Internet of Things (IoT), and the ubiquity of GIS. Although innovation will be widespread, when considering the most disruptive themes of 2018, we will focus on artificial intelligence, autonomous vehicles, the as-a-service business model, sensor fusion and mixed reality.

Artificial intelligence running deeper

Some of the brightest minds in education, technology and business predict artificial intelligence (AI) will change everything. AI is described by the World Economic Forum as one of the key societal advancements that will define the Fourth Industrial Revolution, a new era of technological disruption building on digitization, mobility and the global connectivity of 4 billion worldwide Internet users by 2020.

By applying the algorithms of artificial intelligence to geospatial data, machines can tell us more about our environment more quickly than humans, an advancement that will transform how we learn, work and live. For example, it is now possible to precisely document and monitor roadside infrastructure like street lamps, road signs and other assets in real time, which will become even more important as autonomous vehicles become more mainstream. When that data is interpreted using artificial intelligence, it can help close the gap between detection and correction of roadside damage to improve public safety.

Deep learning, another flavor of AI that refers to deep artificial neural networks within software that can solve problems, is improving image recognition in geospatial data. The newest version of Trimble's image analysis software, eCognition 9.3, for example, leverages deep learning technology from the Google TensorFlow library, empowering customers with highly sophisticated pattern recognition and correlation tools that automate the classification of objects of interest for faster and more accurate results. The Trimble eCognition Palm Oil app, for example, uses leaf structure to detect palm trees in a block or on a plantation to help farmers assess the spacing and health of their trees.

Continued deployment of AI will broaden the range of geospatial data analysis and information that can be automatically extracted to improve decision making.

Autonomous vehicle ripples

Artificial intelligence also is integral to autonomous vehicles, which will rely on real-time positioning and accurate, detailed maps to negotiate urban and rural areas. Autonomous consumer vehicles in rapid development by Tesla, Google and Uber are producing technology advances that also will benefit geospatial solutions providers. These include compact, affordable infrared LiDAR systems that are aided by a micro-electro-mechanical systems (MEMS) and use a rotating laser, and solid-state LiDAR systems. Applied to the geospatial industry, these components will make it cheaper and easier to maintain and calibrate equipment such as optical total stations and scanners.

Autonomous vehicle systems need high-precision data about the roadway and the assets around them, and geospatial professionals will need to capture accurate data on roadside assets for autonomous vehicle systems.

In addition, the positioning and visualization technologies that are a critical component of autonomous vehicles will expand into other transportation applications, such as freight hauling, to use Internet-connected sensors for position, temperature and other data to track the location and status of perishable cargo.

As-a-service adds flexibility

Geospatial customers are increasingly seeing geospatial solutions as a service, rather than a piece of equipment, with the as-a-service model enabling technologies, such as precise positioning, to reach more people so they can improve their workflows and projects.

The Trimble Catalyst GNSS (Geographic Navigation Satellite System) software receiver, introduced to the market last year, has transformed core GNSS technology into a subscription-based software service for mobile devices with a range of accuracy levels down to centimeter precision.

This means more people can to use their smart phones to receive the satellite data for a precise position, a technology advancement that will multiply the capability of a field organizations to increase the reach and rapidness of data collection.

Utilities are one example of the kinds of organizations that want to expand field crews in certain seasons or under various circumstances, but don't want to invest in more hardware.

The response to positioning-as-a-service will vary by world region depending on education and comfort levels with on-demand subscription-based services, but early adopters and software integrators will produce more innovative, less traditional uses, such as event management, explosives disposal, golf course landscaping, trail management, irrigation consulting, farm infrastructure and address allocation.

Solutions from sensor fusion

In the past, we had a cell phone for communication, an iPod for listening to music, and a laptop for internet browsing. Now with smart phones, we have all of those in one device. A similar trend is unfolding in geospatial technology with the fusion of different kinds of sensors, whether GNSS, accelerometers, gyros, magnetometers, barometers or optical sensors.

Sensor fusion combines multiple different sensors in a way that maximizes their combined strengths and minimizes their combined weaknesses. What's exciting currently is the growing accessibility of the technology through advances in control technology and computation, and sensor miniaturization, which will have an impact across all industries, particularly in guidance systems used in autonomous vehicles and mobile mapping systems. The combination of different sensor technologies also will help solve geospatial problems including position availability, system usability and update rates, especially as advances on all sensor fronts helps bring down costs.

Modeling new realities

Mixed reality, which integrates digital content with the physical environment to provide an enriched perspective of those assets coexisting, is providing powerful tool for surveyors, architects, contractors, engineers, and clients by removing the constraints of 2D screens.

Mixed reality technologies accelerate design work, allow stakeholders to experience designs in an environmental context, and enable decisions at inception. The technology requires both hardware, such as Microsoft HoloLens or DAQRI Smart Helmet, and software, such as Trimble SketchUp Viewer for HoloLens and Trimble Connect.

Emerging mixed reality technology will transform GIS by placing visual assets where they reside in a database mapped by a surveyor to improve the decision-making process, such as where to dig safely around underground utilities. While still in the pilot phase, Trimble SiteVision, which combines Trimble Catalyst with Google Tango technology, is one example of a proven solution that makes mixed reality efficient and accessible for everyday use.

Geospatial technology also will play an increasingly important role in Building Information Modeling (BIM), which offers strong capabilities for modeling and visualization. The building construction industry is filled with opportunities for improved efficiency and productivity through BIM, which also is expanding into civil infrastructure, utilities, power stations and industrial facilities. With close collaboration among project stakeholders as one of the key benefits of BIM, cloud-based services and new software tools for visualization will increase BIM's efficiency and effectiveness over time.

GPS and vehicle signal simulation in automotive testing

Mark Sampson
Product Manager, LabSat, Racelogic

Complex vehicle safety and autonomous systems naturally require test and validation of the multiple data streams that feed them. As ADAS edges towards its development apogee, and with truly autonomous vehicles becoming a reality, the testing of these systems will require some lateral thinking to keep the development cycle under control. Any work that can be undertaken on the bench rather than the test track can reduce time and fiscal overheads.

Because they are in command of them, a manufacturer should be able to recreate, on the test bench, all of the control signals required by autonomous systems and infotainment. Except, that is, for GPS. This is a problem if the system under test requires a satellite fix – how do you go about bench-testing when the only way to get it is to go outside?

GPS simulation may not be a process that many vehicle test and development engineers have come across, or researched. It is, however, a method that has been used in the development of GPS-enabled products for as long as there has been a usable civilian signal.

In 2008, Racelogic - who for more than a decade have been supplying GPS-based test systems to vehicle and tyre manufacturers – needed a device capable of generating a realistic satellite signal to aid in the development

The reproduction of GPS signals allows for such parameters as receiver sensitivity, signal acquisition, and firmware consistency to be developed and then tested in the laboratory. The immediately obvious benefit is one of absolute convenience – but it isn't just this that makes the case for GPS simulation so compelling: consistency and repeatability are vital. A simulator can replay, as many times as required

of their high-accuracy VBOX data loggers. Consequently they created LabSat, which records raw, 'live-sky' RF satellite signals for later replay, giving their engineers and production staff an easy and accessible method of putting all of their data logging equipment through a repeatable and consistent bench-test regime.

Traditional simulators had been regarded as a very expensive luxury, which was largely the case; but by employing a record and replay technique and being far more reasonably priced, LabSat quickly established an enviable reputation for using 'real' GPS signals that engineers valued. As a result, a number of chip and mobile phone manufacturers are increasingly placing a LabSat on each of their developer's desks, favouring the one button start/stop functionality that enables them to concentrate on the test results rather than managing the simulator.

The reproduction of GPS signals allows for such parameters as receiver sensitivity, signal acquisition, and firmware consistency to be developed and then tested in the laboratory. The immediately obvious benefit is one of absolute convenience – but it isn't just this that makes the case for GPS simulation so compelling: consistency and repeatability are vital. A simulator can replay, as many times as required, such parameters as signal strength, satellite almanac, obscuration, and multi-path signal reflection. This means that in comparison to outdoor testing where conditions will vary, a new system can be lab-developed and edge cases tested time and time again in the knowledge that the signal input is always the same.

As the number of satellite constellations continues to grow, there is a requirement to ensure that each set of signals can be utilised: as well as the American GPS network there is also Russian GLONASS with worldwide coverage; Chinese BeiDou with Asian coverage currently but with global intentions; Japan-only QZSS; and local SBAS services (Satellite-Based Augmentation Systems). Using a LabSat it is possible to test with a combination of some or all of these signals simultaneously, ensuring that the device is capable of global operation.

Recording raw RF GPS data means that when it is replayed it is entirely realistic: in other words it will replicate the issues commonly encountered when making a journey on public highways – such as multipath or just plain loss of satellite reception due to obscuration from buildings or trees. The vehicle systems can therefore be tested against these environments and adjusted accordingly. However if a 'pure' simulation is required, it can be created in the SatGen software which produces custom scenarios for any kind of dynamic, length of time, or location. One of the advantages in using a generated scenario like this is the ability to replay data that would be dangerous to attempt on a live track – customisable velocity and acceleration allows for system testing outside of sensible driving parameters.

The LabSat is now employed in a wide variety of industries, and given Racelogic's existing client base within the automotive sector it was no surprise that it found favour with a number of vehicle manufacturers, needing to integrate various signal streams, in developing their navigation systems. Most inbuilt satnav units rely on inertial input as well as that of GPS so that they can continue to operate in areas where the sky is no longer visible (tunnels) or is partly obscured (the 'urban canyon' phenomenon).

A simulator or record/replay system needs to be able to replicate the multiple signals that enable the development of dead-reckoning units if it is to be considered as a companion to traditional outdoor, on-track development. A DR system and connected vehicle sensors can be bench-tested by employing a LabSat turntable to replicate vehicle movement and the LabSat can also reproduce previously recorded vehicle CAN, synchronised to within 60ns of the GPS data, as well as serial and digital inputs. There is plenty of scope for those wishing to evaluate their ADAS and autonomous signal streams in conjunction with that of GPS.

Most GPS-enabled products can be developed and tested using signals that have been recorded or generated with a timestamp from the past. But there are some applications which require a current satellite time signal – such as testing low-dynamic Hardware in the Loop systems - and to this end the forthcoming LabSat RT can produce real-time output. With a latency of only one second, GPS data can be fed into a device under test with the current satellite timestamp – a necessity for anything connected to the internet or reporting back to a central server, for instance – with implications for the development of connected cars in the future.

An amazing period for real time GNSS positioning

Thibault BONNEVIE
CEO, SBG Systems

Robust positioning in a lot of challenging environments is at the heart of SBG Systems DNA for now more than 10 years. We are at the forefront of Inertial Navigation Systems, fusing motion sensors and GNSS signals to enable continuous mobile positioning for innovative markets such as robotics, surveying, driverless car navigation, defense, etc. Our customers are coming from such different industries, all over the globe, with both real time and post-processing needs. At the core of those exceptional changes is our industry, we can see two huge trends: a phenomenal expectation on real time positioning accuracy and reliability, and an increasing need of accurate 3D maps.

Professionals working on real time GNSS positioning are facing an amazing period with the modernization of current constellations and the arrival of a new promising one: GALILEO. This newborn delivers higher data availability and comes with very high compatibility with the existing constellations, promising a higher performance when mixing GALILEO signals with GPS, GLONASS, or BEIDOU. This great opportunity comes with the challenge of how to handle these new GALILEO signals and best mix them with the existing ones to obtain the best performance in all conditions. All the algorithm design teams face a total new constellation with lots of parameters to handle, synchronise, correct, and compute.

> We can see two huge trends: a phenomenal expectation on real time positioning accuracy and reliability, and an increasing need of accurate 3D maps

GALILEO is part of the other big advancement in real-time GNSS: the enhancement of the Precise Point Positioning (PPP) technology with the goal of a centimeter-level position. Getting rid of infrastructure and reaching the centimeter-level accuracy with a shorten fixing time is a dream for many integrators and could reduce the time on market of several projects.

If the arrival of GALILEO and the improvement of the PPP technology are amazing opportunities, some markets relying on the GNSS technology will continue to face technical challenges. When we speak about real-time performance in the GNSS industry, we talk about precision, availability but also reliability.

Reliability is the key of markets based on real-time GNSS positioning. Lots of outdoor human tasks tend to go unmanned such as agriculture, surveying, or driving. Positioning is the core of these systems, and GNSS is only one of the solutions. Even if the availability of satellite is greatly increasing, there will always be obstructions between the mobile and the GNSS signal. The GNSS signal cut could be due to masks such as urban canyons, forest, mountains, tunnels, or intentional spoofing. GNSS integrators need to find the right additional technology that will ensure robustness in their navigation solutions, at the right size and price. They will even need more than one sensor to ensure safety and will rely on aiding equipment such as LiDARs, odometer, vision, and inertial navigation systems. The challenge here is to take the best of each technology. This is another big task for the algorithm design team. How to best handle positioning in areas where GNSS is disturbed by taking into account those aiding technologies, the platform, the conditions of use, etc. Intelligence is the most valuable element in the positioning chain. For example, the tight integration of GNSS with Inertial Navigation System (INS) is a great way to improve robustness by deeply taking into account all the parameters of the GNSS fix (ephemerides, number of satellites, etc.) with the raw inertial data. Moreover, filtering can integrate odometer aiding data when the application is car-based, LiDAR when obstacles are close to the equipment, etc. This complex computation results in a more precise and robust real-time trajectory, consequently improving the reliability of the overall solution.

> GNSS technology promises a lot of improvements in term of accuracy and availability. But is the biggest challenge to make it easy-to-use and affordable?

Additional challenges are appearing in the driverless car industry: the need of miniaturized sensors, volume, and price huge drop. Their searches for safety could conduct them to rely on several sensors. But what could be the budget of safety? Is the technology ready enough?

If the driverless car industry is still quite in the research and test phase, this market is a good field for implementing the best of the positioning technology while increasing the need of more detailed and precise maps.

From taking manually one point at a time to design 2D map to collecting the full environment with thousands of 3D points using vehicle-based surveying solution, cartographic applications have been revolutionised. Data are now collected on site, and then sent directly to the office team, located anywhere on earth and ready to post-process them. The need of more precise geographical data coincides with new abilities to collect them in large volume. This enhanced workflow encourages the use of post-processing to obtain higher accuracy and solve some of the issues encountered on the field. This "forward-backward" algorithm uses past as well as future registered positions (from GNSS, Inertial and other sources) to increase the accuracy of the current position. This higher level of performance could save hours of data treatment. This also enables today's new extremely portable systems based on UAV LiDARs data.

Whether the use of GNSS positioning is real-time or post-processed, this technology is more and more used in consumer applications such as Internet of Things, Artificial Intelligence, Automation, Virtual Reality, etc. Integrators are specialized in their industries, not in positioning. They are searching for powerful and easy-to-integrate solutions, even plug and play. The challenge here is to democratize the most complex positioning solution by adding User Experience (UX) design in all positioning technologies developments as well as algorithms that will help and even compensate some of human mistakes. For instance, inertial sensors need to be installed properly, with a specific alignment. If there is an issue in the installation, the embedded algorithm will be able to correct all the data, so that the overall equipment can work.

GNSS technology promises a lot of improvements in term of accuracy and availability. Yet, there is a lot of work to be done in algorithm design to fully benefit from it; and another effort will be necessary to complete GNSS technology with other sensors to maintain the best performance in all conditions. But is the biggest challenge to make it easy-to-use and affordable?

Photogrammetric drones are innovative tools

Jean-François Baudet
CEO, Hélicéo

The vast world of geomatics is strongly impacted by new technologies of production and digital data processing. These make it possible to describe the territory and to determine geographical positions using GNSS satellite positioning. Photogrammetric drones are innovative tools that have a great influence on this universe. Indeed, these UAVs prove to be much more efficient than the survey methods traditionally used by surveyors. They bring a real time and money saving to the operators, but also guarantee them more safety. Intelligent drones are increasingly meeting the needs of measurement professionals.

> To make faster, more precise and safer with drones, here is the real revolution for the world geomatics. On the other hand, the LiDAR, very use on autonomous cars of the future to see and move, is already very present to scan and measured in our world of the Survey

Thanks to their automation and the development of Real Time Kinematic (RTK) technology, they can map large-scale scenes very quickly and with very high accuracy in real time. Then, these can be reconstructed in 3D through point clouds, orthophotographs, or digital terrain models (DTMs). Many trends are spreading in the field of geomatics. For example, there is bathymetry which is the science that determines the topography of the seabed. Indeed, drones are increasingly used in the measurement of underwater depths. In addition, one of the major challenges currently facing geomatics companies is lasergrammetry. This technology occurs where photogrammetry has limitations. Using a laser device called LiDAR, embedded on a drone, it is possible to calculate the distance between a point A and a point B with centimetric precision. The aerial, terrestrial or aquatic lasergrammetry brings very important gains. These gains are of several orders. The first concerns the possibility of scanning smooth and complex shapes as there are many in our urban worlds. LiDAR precision also allows you to scan very thin objects such as high voltage lines or railroad tracks (what photogrammetry can not traditionally do). The second significant point is the reduction of treatment times by a factor of 10 compared to photogrammetry. Indeed, if several hours of processing are necessary in photogrammetry LiDAR data are almost real time. Last point, LiDAR information is smart, thanks to the multi echo. For example, it is possible to obtain a first classification between vegetation and soil, which for the world forestry is very useful.

In conclusion, to make faster, more precise and safer with drones, here is the real revolution for the world geomatics. On the other hand, the LiDAR, very use on autonomous cars of the future to see and move, is already very present to scan and measured in our world of the Survey. Decidedly we live a very rich time in major innovations.

Navigating the fourth industrial revolution

Jean-Christophe Zufferey
CEO, senseFly

Wider technological advances have seen the geospatial industry strengthen in recent decades, with disruptors such as real-time kinetics (RTK) transforming data collection. Alongside other revolutionary developments in technology, such as artificial intelligence, robotics and automation, many believe that the world is now entering what is known as the fourth industrial revolution (4IR). With greater connectivity and improved processes expected thanks to these innovative technologies, professionals across a variety of verticals will be able to gather more in-depth insights at a faster rate and make real-time decisions.

Agile and automated

While the 4IR movement is still in its infancy, these technological innovations have already started to have a significant impact on the geospatial industry, with robotics, and unmanned aerial vehicles (UAVs), working with other devices to improve automation and make processes more efficient than ever before. For example, operators and service providers can now be better connected to their customers by using more diverse data sources to update maps, while agile development methodologies are facilitating shorter innovation and production cycles to deliver products more quickly to market. Indeed, we've seen evidence of this both at senseFly and across the industry, with new technology projects released every year.

As a business active in a wide range of sectors, we've learned how important it is to remain at the forefront of technological developments and be on the pulse of market changes to meet the needs of our customers. At the same time, technological innovations—especially the software that forms a major part of our products—enable us to improve our products and service offering on an ongoing basis. We provide continuous updates and support, which allow customers to benefit from innovative features without having to invest in new hardware. Strategic partnerships, such as those senseFly has created with software providers like Pix4D, AirMap and Airware, help to facilitate this, offering an end-to-end, connected drone solution that makes processes more automated, integrated and efficient, which ultimately improves business operations.

Refining technologies

While automation is, to some extent, already integrated into a number of verticals and processes, high accuracy Global Positioning Systems (GPS) such as RTK will increase its possibilities. For instance, the automotive industry is already using geospatial data and taking a collaborative approach to develop autonomous vehicles—a trend mirrored in the drone industry. Integrated UAV solutions are utilising this data to enhance UAV surveying and mapping capabilities, from automated flight planning and execution, to sensors able to visually recognise obstacles and objects during flight. Other emerging technologies, such as artificial intelligence, Big Data and the Internet of Things (IoT), are also continuously being refined. It is clear, however, that the convergence of these technologies may revolutionise the future of rapidly evolving sectors like the automotive, drone and electronic industries, with Big Data set to offer more precise, accurate processes and inform decision-making.

The future of geospatial

Innovation and disruption are at the core of most major advances, and, when successful, have the power to change the future of an industry. While these developments clearly offer significant promise for businesses in geospatial and their customers, it is essential that we as an industry evolve in line with the fast-changing nature of these technologies. Balancing the need to improve products' efficiency and performance with safety will be crucial. For instance, at senseFly, a robust, well-trained workforce has proven to have significant, tangible benefits on our ability to adapt to, and work with, emerging technologies. This talent enables us to remain on the cutting edge of the latest technological advances and ever-changing regulatory landscape, ensuring we are always ready to use these insights to better meet our customers' needs. As regulations become clearer and drone technology becomes simpler and more integrated with innovation, we anticipate that such pioneering advances will support more widespread adoption of drone technology, and enable the UAV industry to continue its upward trajectory.

While the 4IR movement is still in its infancy, these technological innovations have already started to have a significant impact on the geospatial industry, with robotics, and unmanned aerial vehicles (UAVs), working with other devices to improve automation and make processes more efficient than ever before

It is a doable task to make an earthquake prediction tool

Dr Ivan G Petrovski
Principal GNSS Engineer, iP-Solutions

Today, it is well established and statistically proven that there is a strong correlation between earthquakes and ionospheric disturbances, which can be observed in particular in electron density NmF2 and GNSS TEC. The first time such correlations between earthquakes and ionospheric anomalies which preceded them were described was by K.Davies and D.M.Baker in 1965 in relation to the big Alaska earthquake of 1964. However, even today these precursors are not used. The largest most recent Tohoku earthquake in Japan in 2011 had distinct precursors in the ionosphere three days in advance, which could be observed, for example, from www.ips.gov.au website, specifically on Low and Mid Latitude 30-day disturbance index plots, where the indexes went off the 10 TECU scale for three days in a row prior to the earthquake.

The main issue with these precursors today is that the amount of data and quality of methods of analysis are not sufficient to utilize these precursors with economic efficiency. In order to use them we have to be able not only to predict that the major earthquake is going to happen in the next couple of days, but to pinpoint it with certain accuracy and estimate its amplitude, in order that the related agencies could justify acting upon these predictions.

The financial benefit should be noticeable, i.e. to act in advance should cost less than to mitigate the results of these events afterwards. If one can predict an earthquake only with relative probability and without knowing the precise location, then the financial losses incurred in acting upon this information will be greater than losses incurred in neglecting the warning, and as a result of such neglect lives could be lost. We hope that in the not-so-distant future humankind will be able to predict earthquakes with certainty by monitoring the Earth's ionosphere. To predict an earthquake means to be able to estimate in advance with given probability time, place and magnitude of the earthquake.

Needless to say, that the golden era of ionospheric research has passed decades ago, leaving us with tremendous advances in radio, navigation and understanding of the Earth's atmosphere.

> The new technology trends would permit better data exchange and availability and better means of data analysis. More efficient and diverse algorithms for data processing can be implemented on cloud using clusters working on digitized intermediate frequency (DIF) signals as well as on raw data, which would allow for much deeper analysis

With new technological trends we can get back to more scrupulous research, as means of data collection such as GNSS receivers with functions of TEC measurements and scintillation monitoring can be used not only by any university, but also individual scientists.

The new technology trends would permit better data exchange and availability and better means of data analysis. More efficient and diverse algorithms for data processing can be implemented on cloud using clusters working on digitized intermediate frequency (DIF) signals as well as on raw data, which would allow for much deeper analysis. The development of artificial intelligence brought us algorithms, which can discern patterns and correlations in large amounts of data on a level which was previously unimaginable.

I think it is one of the really important challenges and based on my knowledge, it is a doable task to make an earthquake prediction tool which will be monitoring ionospheric conditions by constantly taking measurements from GNSS sensor networks. Today we can use GPS, GLONASS, QZSS, Galileo, BeiDou and IRNSS satellites in L1, L2, L5 and S frequency bands, put these data on the Internet and process them with AI algorithms. We already have a significant amount of raw data from over a thousand stations from networks, such as IGS and GSI, occultation experiments such as CHAMP/GRACE and various data assimilation methods, however only raw data, such as various GNSS observables can currently be collected and processed.

There are no GNSS networks today which can provide DIF data and not so many tools similar to the tool we have developed to process such data with sufficient accuracy and efficiency. There is a need today for such GNSS networks which would allow scientists and researchers to access signals in DIF format from GNSS satellites on all frequencies, to advance further in atmospheric research, ultimately to predict short- and long-term weather anomalies and natural disasters, such as earthquakes in particular.

LiDAR has crucial role in driverless automobiles

Christian Sevcik
Manager Strategic Software Alliances, RIEGL Laser Measurement Systems GmbH

Technology, as a whole, rapidly changes and shifts daily with new and exciting developments constantly being introduced. These major shifts, not only in our industry but in our day-to-day lives, have been coming from new technological developments such as the Internet of Things (IoT), Artificial Intelligence (AI), Automation, Robotics, Driverless Automobiles, Wearables, Nano-Tech, Big Data, 3D Printing, Crowd Monitoring, Cloud, and AR/VR/MR, amongst many others. The influence of these quickly growing technologies can be, and has been, felt in many aspects throughout the industry, as well as our company personally.

With our focus on providing the most cutting-edge pulsed time-of-flight LiDAR technology in airborne, mobile, terrestrial, industrial, and unmanned laser scanning solutions, we constantly have to stay aware and current with all of the shifts and changes that occur with technology. In order for us to provide the most groundbreaking solutions for our users, to develop the technologies needed to push into new markets and to stay on the forefront of revolutionary systems and solutions, we have to acknowledge the new technologies arising, adopt and work with the ones that apply to our technologies, users, markets and applications and then adapt to the ones that affect our lives.

One of the best examples of this is how we work with the Internet of Things and the Cloud in a symbiotic cycle. With the advanced connectivity capabilities of our laser scanners, they can contribute to the Internet of Things as a part of the network of devices that are embedded with electronics, software, sensors, and network connectivity that allow them to connect and exchange data From that point, this data collected from our scanners can easily be uploaded into the Cloud for users worldwide to access remotely, use remotely, and view remotely. This is just one example of how the influence of these technological developments currently affect us directly.

One of the founding units that our company developed, manufactured, and distributed for the industrial sector has been used to aid and assist in automation at factories for years. These distance meters still are able to be used to help with current automation processes and to develop better workflows to make the processes simpler, more efficient and safer.

As for robotics and LiDAR, our LiDAR sensors have been integrated into robotic units to allow for the safety of the human user while guaranteeing the highest accuracy possible of acquired data in hard-to-reach or generally unsafe areas. This same principle also currently applies to another burgeoning technology that is rapidly expanding: unmanned technology: this growing sector also is causing a lot of technologies to grow, adapt, and change to meet the needs of the people. LiDAR itself has also become a highly visible and prevalent component in aiding and assisting the promotion and development of driverless automobiles. LiDAR serves a crucial role in driverless automobiles, as the detection and ranging that it provides allows these cars to essentially have a "driver" able to detect distance from objects, map the world around the car, and provide them a safe experience on the road.

As for technological trends and innovation challenges that we anticipate seeing, one of the ones we would like to continue to see and that we are seeing is a growing need for LiDAR and LiDAR services in many markets and applications to help fuel the fire for these new technologies. One of the things that LiDAR helps to provide is a basis for these new, emerging technologies to flourish and grow. The data that we are able to collect with LiDAR helps to further the development of these up-and-coming technologies and will additionally help future technological advancements to emerge, as well.

Technology is constantly changing. It is exciting to watch as the world shifts and it's exciting for us to grow with these changes. It presents fantastic opportunities for us to tackle new challenges, try new things, and to expand into new markets, applications, and fields. As new technologies emerge, it is up to us to figure out what role it plays in our day-to-day in our lives, as well as our business.

Vulnerability mitigation strategies for GNSS-based PNT applications

John Fischer
VP Advanced R&D, Orolia

Hikers, skippers and taxi drivers – everyone uses and blindly trusts GNSS today, and this dependence will likely increase in the future.

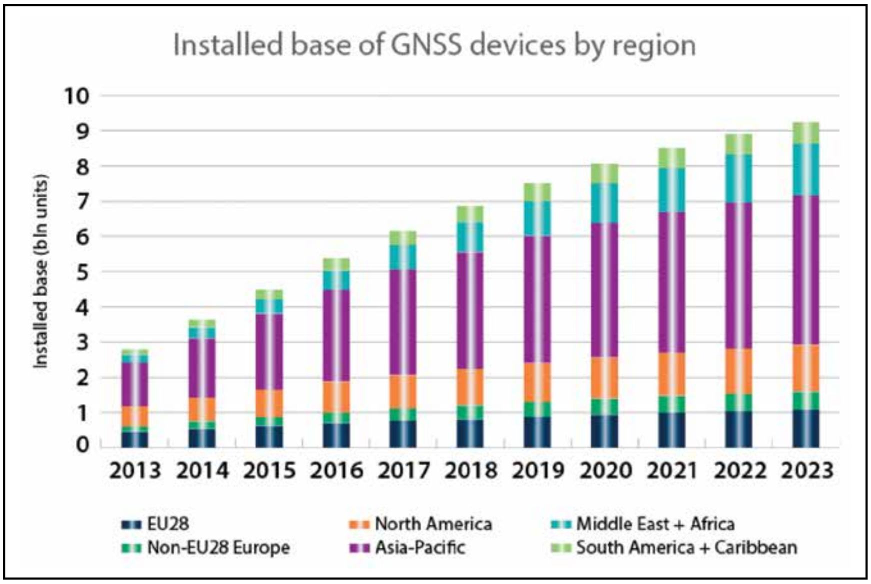
But besides personal users who benefit from satellite-based navigation applications, GNSS has also been woven deeply into the fabric of critical technology that is used across many industries today: GNSS-based time plays a key role in the operation of communication networks, financial systems or power grids.

As commercial GNSS applications are becoming more complex and fast-paced, technical change is now a constant companion. Assessing the risks and developing a mitigation strategy for GNSS-based applications are no easy tasks, yet developers, owners and operators of many GNSS-based applications must implement mitigation strategies into their products or systems to address potential vulnerabilities.

GNSS by the numbers

- 7 billion GNSS devices are predicted to be in use worldwide by 2022 (a 9% annual increase).
- 16 industries have been identified by the U.S. Department of Homeland Security as critical to the U.S. infrastructure:

- ▫ Chemical sector
  - ▫ Commercial facilities
  - ▫ Communications sector
  - ▫ Critical manufacturing
  - ▫ Dams sector
  - ▫ Defense industrial base
  - ▫ Emergency services
  - ▫ Energy sector
  - ▫ Financial services
  - ▫ Food & agriculture
  - ▫ Government facilities
  - ▫ Health & public health
  - ▫ Information technology
  - ▫ Nuclear reactors, materials & waste
  - ▫ Transportation system
  - ▫ Water & wastewater
- 5 performance parameters are key to applications considered liability or safety-critical, according to the European GNSS agency: Integrity, continuity, robustness, availability, and accuracy.
- 1.5 microseconds network synchronization accuracy is a frequent requirement for the Telecom industry is required to maintain a network synchronization accuracy of 1.5 us (Source: ITU Recommendation G.8271/Y.1366 (07/16))
- 100 microseconds is the time synchronization accuracy requirement by MiFID II for the financial market in Europe.
- Human dependency on GNSS will continue to increase, with ever-more technology trends relying on GNSS: Big data, fast data, autonomous transportation (ships, trucks), driverless car, Smart Factory, Industry 4.0



(Source: European GNSS agency)

Understanding GNSS' vulnerabilities

In the context of today's heavy reliance on GNSS for PNT purposes, the vulnerabilities of GNSS signals are becoming increasingly relevant. To better understand the threats against GNSS, its vulnerabilities are typically divided into two categories: jamming and spoofing.

Jamming

Jamming generally refers to intentional interference by means of a radio-frequency signal. Interference sometimes is used in the context of natural causes such as atmospheric phenomena. The effect is the same for both: The ability of the GNSS receiver to extract GNSS signal information from the background noise is impaired or rendered impossible.

There also is unintentional jamming: RF transmitters bleeding into the GNSS frequency bands are often the source of this.

Illegal consumer-grade GPS jammers (also referred to as Personal Privacy Devices, or PPDs) fall under the category of intentional jamming, even though they typically target a different receiver. For example, nearby stationary receivers are "merely" collateral victims of the jamming event. These devices may become more popular over time as public concern over personal privacy grows.

Spoofing

"Spoofing" is the act of broadcasting false signals with the intent of deceiving a GNSS receiver into accepting the false signals as genuine.

From a technical perspective, spoofing GNSS receivers is more challenging than jamming, but the consequences are more severe because the receiver uses the manipulated signals for PNT calculations (rather than rejecting it), and neither the system nor the operator realize that the indicated PNT data has been corrupted. Spoofing can therefore relocate the receiver, which is not possible with jamming.

Spoofing is not an easy undertaking, especially if the spoofing target is moving fast. But it has been done, and the threat is considered real – and growing – by both government departments and private critical infrastructure operators.

Interference Detection and Mitigation (IDM)

So what makes a PNT application resilient against spoofing and jamming? The answer is best illustrated by the image below which depicts the different technologies that can be used to augment a PNT solution to obtain a technically well-diversified selection of alternative PNT sources.

The overarching objective in the selection of augmentation sources should always be a mix of different technologies and different platforms; e.g., terrestrial vs. space-based, microwave vs. long wave, etc., thereby decreasing the likelihood that an interference impacts more than one PNT source.

Protecting against Interference

The objective here is to prevent the unwanted or corrupted signals and data from entering the system in the first place. This can be accomplished by using electrically steerable directional antennas, which are also called Controlled Reception Pattern antennas (CRPA), or "smart" antennas. Another approach to protect a GNSS receiver against jamming is the horizon-blocking antenna. This type of antenna will reject signals transmitted near the horizon, because these are more likely to be ground-based jammers.

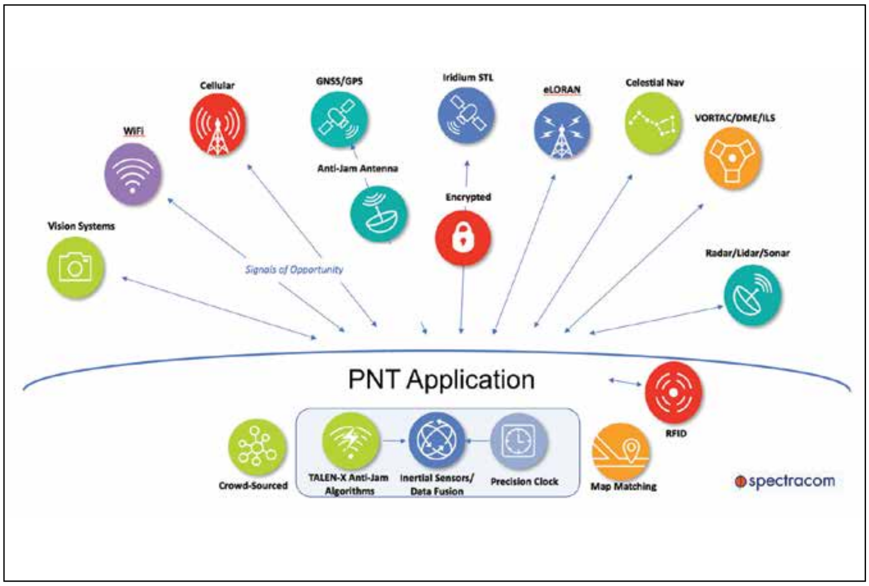
Detecting Interference

Next to protecting against interference e.g., by using "smart" antennas, or horizon-blocking antennas, the prompt and correct detection of an interference event is key to alerting the user(s) of a GNSS-based PNT system about the presence of a threat. GNSS receivers are increasingly often equipped with jamming-detection functionality that will inform the user of a jamming/denial situation, offering at least the option of quicker diagnostics in the event of an unexpected signal loss. Also, multi-GNSS chipsets in modern receivers often offer integrity monitoring between GNSS systems. However, the level of monitoring capability varies widely and system integrators often have little control over these settings.

A relatively new approach to detecting jamming or spoofing attacks is a software that monitors the GPS signal frequency band by applying error detection algorithms: Spectracom's SecureSync platform now supports Talen-X's BroadShield software that can detect if the GNSS receiver is being spoofed and, in the event of a signal loss, can provide valuable information as to why the signal has been lost.

The software's algorithms can discern a jamming event caused by natural events that cause the signal to weaken. If a monitoring signal threshold value is exceeded, the SecureSync time server will emit an alarm and invalidate the GPS reference before it can pollute the internal time base. Now, when SecureSync transitions into Holdover, it "flywheels" on the previous pure reference signal.

Another software-based approach is the reference monitoring software: This type of software can run on time servers, which, next to GNSS, have additional timing reference inputs, such as an IRIG input and/or a PTP reference. The software will compare these references continuously: If the GNSS reference exceeds a software-determined phase error-based validity threshold value, which suggests a jamming or spoofing event, the software will automatically issue an alarm.



Mitigating Interference

Interference mitigation is the second aspect of the IDM approach: Isolate the unwanted signal, then quickly reject and replace it, causing minimal system degradation. In essence, this involves the use of augmentation technologies and diversification strategies to supplement GPS/GNSS, thus reducing the dependence on it.

Another well-established technical approach to deal with temporary loss of GNSS signals is holdover solutions, such as oscillators for timing, and Inertial Navigation Systems (INS) for navigation systems.

Signals of Opportunity, such as WiFi and cellular signals, also often fall into the crowdsource category, since these opportune signals are often "borrowed" from systems that were not designed for PNT purposes.

A new mitigation technology is a system called STL (Satellite Time and Location): STL provides an alternate space-based PNT source to the GPS constellation. It re-purposes the Iridium system's pager channels to provide a PNT signal accessible by terrestrial receivers.

This system is operational and available today. Because the satellites orbit Earth on a much closer orbit, the signal is >30 dB stronger than GNSS signals. The signal can, in fact, be received indoors, as it is a much narrower band signal than a standard Iridium comm channel, and it is more resistant to jamming and interference. The STL signal is encrypted; users are assigned a subscriber key to decrypt the signal.

Conclusion

Solutions to make PNT systems resilient against vulnerabilities are continually evolving, but detection and mitigation technologies exist today that can be used in combination with GNSS-based PNT equipment, allowing us to continue to rely on trusted GNSS as the main source for positioning, navigation and timing.

SPOOFER BUSTERS

Spoofers are not only of the Black Sea type, as reported in the press, kids are going that direction too. It is time to take spoofers seriously.

Spoofers are completely different from jammers that block GNSS signals. Spoofers create GNSS-like signals that fool receivers to provide false location solutions.

PATENTS PENDING

We combat spoofers in two ways:

1. Detect and alarm that spoofer exist.
   We ignore the spoofer and use valid satellite signals.
2. Help find the direction that spoofed signals are coming from.

Spoofer detection is available in all of our OEM boards.

See details inside

JAVAD

www.javad.com

Front

Spoofer Detection

PATENTS PENDING

With 864 channels and about 130,000 quick acquisition correlators in our TRIUMPH chip, we have resources to assign more than one channel to each satellite to find ALL signals that are transmitted with that GNSS satellite PRN code.

If we detect more than one reasonable and consistent correlation peak for any PRN code, we warn you that you are being spoofed and identify the spoofed satellites.

When we detect that spoofing is in effect, we use the position solution provided by all other clean signals (L1, L2, L5, etc... GPS, GLONASS, Galileo, Beidou, etc...) to ignore the spoofer signal and use the real satellite measurement. If all signals are spoofed, then we alarm you to ignore GNSS and use other sensors in your integrated system.

The screenshots below are from a real spoofer in a large city. The bold numbers are for the peak that is used in the position solution.

Satellite Name	First Peak: Signal above noise level	First Peak: Range mod 1 ms	First Peak: Doppler	Second Peak: Signal above noise level	Second Peak: Range mod 1 ms	Second Peak: Doppler	Delta range	Delta Doppler	Noise level
SAT	SNR 1	Range 1	Doppl 1	SNR 2	Range 2	Doppl 2	dRange	dDoppl	Noise
GPS1	**15**	**2.51**	**-4130**	13	28.59	-4030	25.06	-100	26
GPS4	**15**	**46.49**	**2849**	5	0.32	4350	18.34	-1501	25
GPS8	12	52.64	713	6	53.52	714	0.14	-1	25
GPS10	**19**	**24.95**	**1020**	12	58.07	1121	31.39	-101	26
GPS11	**16**	**3.66**	**-3492**	13	2.37	-3392	0.28	-100	26
GPS13	11	51.31	2103	5	52.19	1804	0.14	299	26
GPS14	**16**	**45.03**	**-3699**	14	62.31	-3599	16.26	-100	26
GPS15	14	62.46	812	5	34.04	413	27.40	399	25
GPS18	**12**	**63.21**	**1878**	13	45.76	1979	16.43	-101	26
GPS20	13	31.68	2275	5	32.27	2076	0.43	199	26
GPS22	12	15.54	-4100	5	16.42	-4200	0.14	100	26
GPS24	**17**	**45.74**	**-881**	12	7.65	-781	26.42	-100	26
GPS27	13	33.87	2603	8	34.75	2704	0.14	-101	25
GPS28	**10**	**7.62**	**-746**	4	15.24	-3446	6.60	2700	26
GPS32	**21**	**41.21**	**-2660**	4	20.54	-2560	19.65	-100	26
GLN-5	23	50.48	-2500	5	8.43	3500	22.47	-6000	22
GLN-3	8	52.83	3840	5	6.30	-1359	17.98	5199	22
GLN-2	**9**	**54.07**	**-3871**	3	15.55	-8671	25.99	4800	23

Esc 1 2

The first or the second peak is the spoofer. Ignore gray numbers which are insignificant peaks.

SAT	SNR 1	Range 1	Doppl 1	SNR 2	Range 2	Doppl 2	dRange	dDoppl	Noise
GPS2	6	41.95	1899	6	11.58	0	29.34	1899	23
GPS4	10	22.72	2502	5	31.40	1803	7.65	699	23
GPS7	**22**	**28.15**	**1303**	6	49.56	4	20.39	1299	23
GPS8	**14**	**1.77**	**-472**	5	1.18	-2472	0.43	2000	23
GPS9	13	16.57	2858	5	44.72	6459	27.13	-3601	23
GPS11	7	50.88	-4100	6	13.34	2100	26.97	-6200	23
GPS13	**17**	**17.59**	**-3371**	5	57.93	-2571	24.17	-800	23
GPS15	**12**	**55.88**	**-4315**	4	33.15	-7015	21.71	2700	24
GPS20	**12**	**60.42**	**-1249**	4	31.10	-2549	28.30	1300	24
GPS21	10	56.01	410	6	17.46	1411	25.97	-1001	23
GPS27	**10**	**58.35**	**1535**	5	48.25	-1164	9.08	2699	23
GPS28	**20**	**51.02**	**-2485**	4	53.95	1815	1.91	-4300	24
GPS30	**23**	**19.51**	**-219**	4	32.87	1981	12.33	-2200	24
GLN-7	**23**	**31.11**	**-751**	5	35.51	4249	3.37	-5000	23
GLN-5	11	40.72	-4899	5	55.18	0	13.43	-4899	22
GLN-4	14	32.50	-4899	4	12.61	2800	18.88	-7699	23
GLN-3	**18**	**36.02**	**1065**	4	15.11	-934	19.89	1999	23
GLN-2	**20**	**42.92**	**2510**	4	30.22	7511	11.68	-5001	24

Esc 1 2

No spoofer. Only one reasonable peak for each satellite.

J-Tip

Integrated Magnetic Locator

$850

No need to carry heavy magnetic locators any more. The J-Tip magnetic sensor replaces the tip on the bottom of your rover rod/monopod. Its advanced magnetic sensor send 100 Hz magnetic values to the TRIUMPH-LS via Bluetooth. TRIUMPH-LS scans the field and plots the 2D, 3D and time view of magnetic characteristics. It also shows the shapes and the centres of the objects under the ground and guides you to it.

PATENTS PENDING

J-Tip advantages:

• J-Tip does not have “null” points around the peak and will not produce false alarms.

• J-Tip is fully automatic for all levels of magnets. There is even no “Gain” button to adjust.

• J-Tip senses the mag values in all directions. You don’t need to orient it differently in different searches.

• J-Tip gives a 2D and 3D view of the field condition when you have RTK and will guide you to the object. You can actually see the shape of buried object.

• J-Tip, In Time View, shows positive and negative mag values of the last 100 seconds and the Min and the Max since Start.

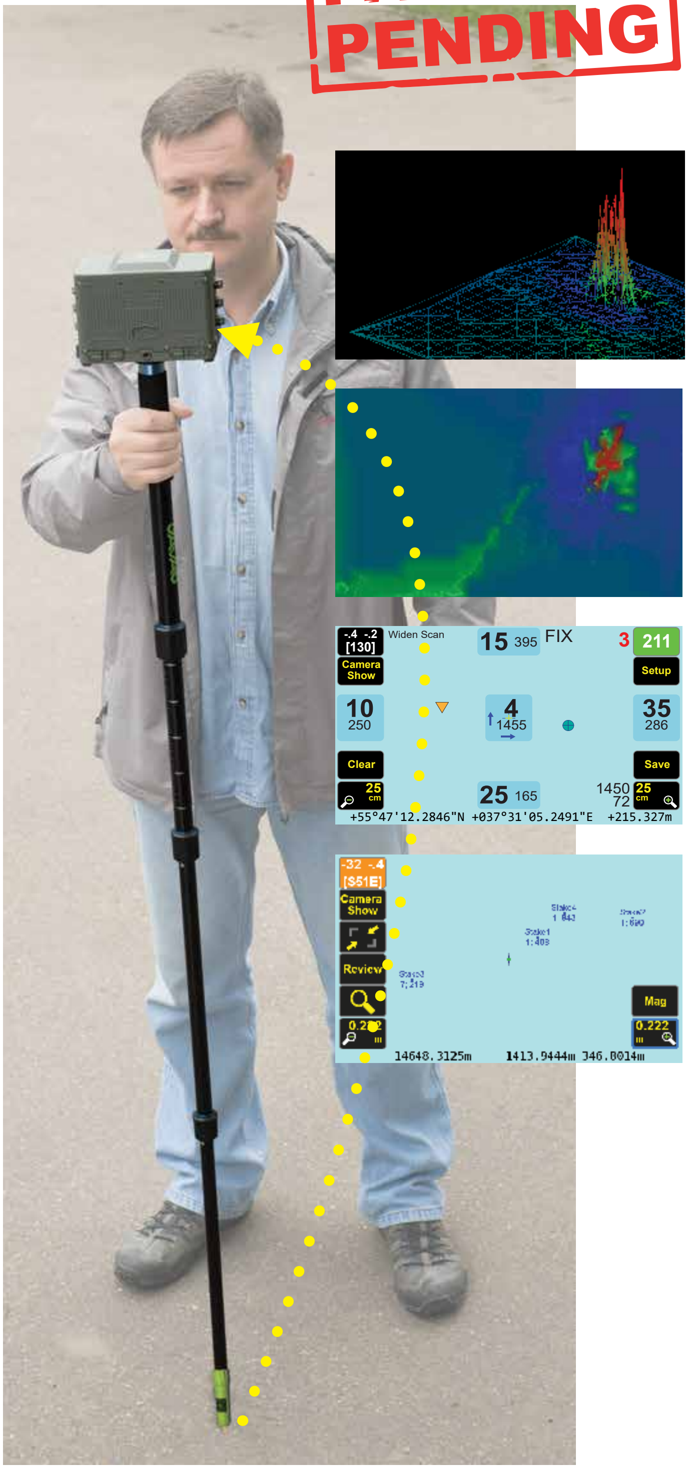
• J-Tip shows the instantaneous magnetic vector in horizontal and vertical directions.

• J-Tip works as a remote control for the TRIUMPH-LS

• J-Tip weighs 120 grams and replaces the standard pole tip. In balance, it weighs almost nothing.

• The built in camera of the TRIUMPH-LS documents the evidence after digging.

• And... you don’t need to carry another bulky device.



J-Pod $850
A rugged Transformer-Pod

J-Pack $290
Convenient survey bag

Javad......Bravo!!!!

The J-Pack is nicest bag I have ever seen for surveying. I especially like the pocket in the back and all of the places to tie down equipment and stuff.

Adam Plumley, PLS

Landing Pads

Monopod >>> to + Bipod >>> to + Tripod...
On demand.

J-Field

Application program of TRIUMPH-LS

Who moved my  base?

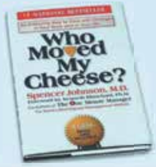
It is well known that having your own base station near your job site provides you with faster, more accurate, more reliable and less expensive solutions. If you don't know the accurate position of your base, our DPOS service will find it. Read details in the following pages.

After you start your base, If during your survey somehow your base is moved, all your rover points will be inaccurate to the amount of the base movement. But...

...But! Don't Worry, Be Happy:

We will let you know instantly during your survey if your base has moved. We use:

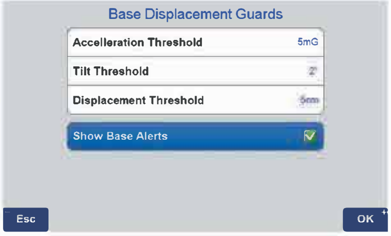
1. Inclinometer which shows the tilt value.
2. Accelerometer which shows motion and shocks.
3. We calculate displacement. This value is accurate to 2 cm.



By the way, a must read book for adult professionals

1

2



3

4

5

6

7

8

1) Set the displacement threshold here. "Off" means ignore displacement. Our default is 5 cm.

2) Click the "Start Base". it will change to "Stop base."
RTK corrections as well as motion values will be transmitted to the rover.
Maximum values of the motion parameters will be kept at all time.

3) Maximum values of the three sensors can be shown in a white box in the action screen. Top left is the acceleration in milliG, bottom left is tilt and bottom right is displacement in centimeter.

4) If any of the threshold values exceeds, a pop up will alert you and shows the maximum value of the sensors since you started the base. The bottom number is time since the threshold(s) exceeded.

5) To setup for base movement alert, go to base rover setup screen and click on the left side of the screen.

6) You can set up threshold limits for accelerometer, inclinometer (tilt) and displacement values to create alert when these thresholds are exceeded.

7) Set Acceleration limit here. The units are in milliG (mG). G is acceleration in free fall. "Off" means ignore this sensor. Our default is 5 mG

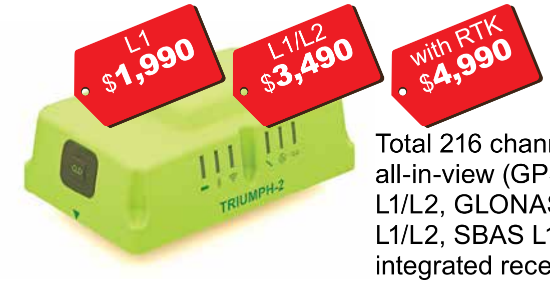
8) Set the tilt threshold here. Units are in degree. "Off" means ignore tilt.
Our default is 5 degrees.

Receivers

TRIUMPH-1M

864 channel chip, equipped with the internal 4G/ LTE/3G card, easy accessible microSD and microSIM cards, includes “Lift & Tilt” technology.

TRIUMPH-2



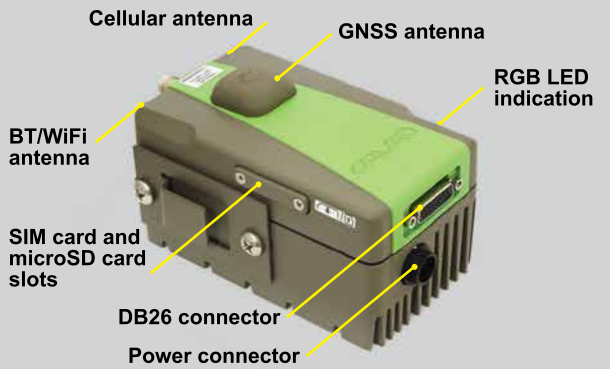
Total 216 channels: all-in-view (GPS L1/L2, GLONASS L1/L2, SBAS L1) integrated receiver.

The one and the only Digital Radio Transceiver in the world!

Unique adaptive digital signal processing, which has benefits: the full UHF frequency range and all channel bandwidths worldwide • the best sensitivity, dynamic range, and the highest radio link data throughput • embedded interference scanner and analyzer • compatibility with another protocols. Cable free Bluetooth connectivity with GNSS receivers and Internet RTN/VRS access via embedded LAN, Wi-Fi, and 3.5G

*Power, data cables and antenna are included.

And all this with competitive prices!



JLINK LTE*

$1,499

Connects all types of devices via UHF, WiFi, Bluetooth, and 4G/LTE for reliable IP communication in the field.

HPT401BT*

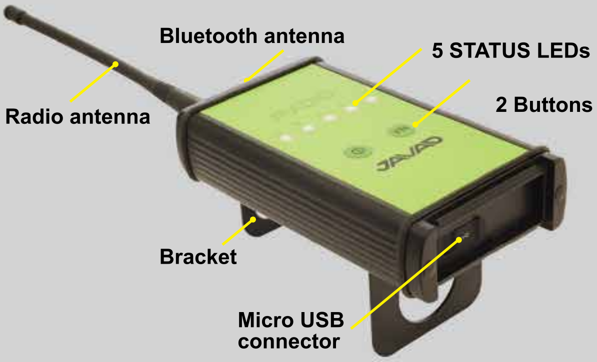
$2,010

1 W UHF transceiver with internal battery. Suitable for TRIUMPH-2 Base or as repeater.

HPT435BT*

$2,710

High power (up to 35 W) UHF transceiver. Suitable for TRIUMPH-1M/ TRIUMPH2 Base or as repeater.



JRADIO*

$1,190

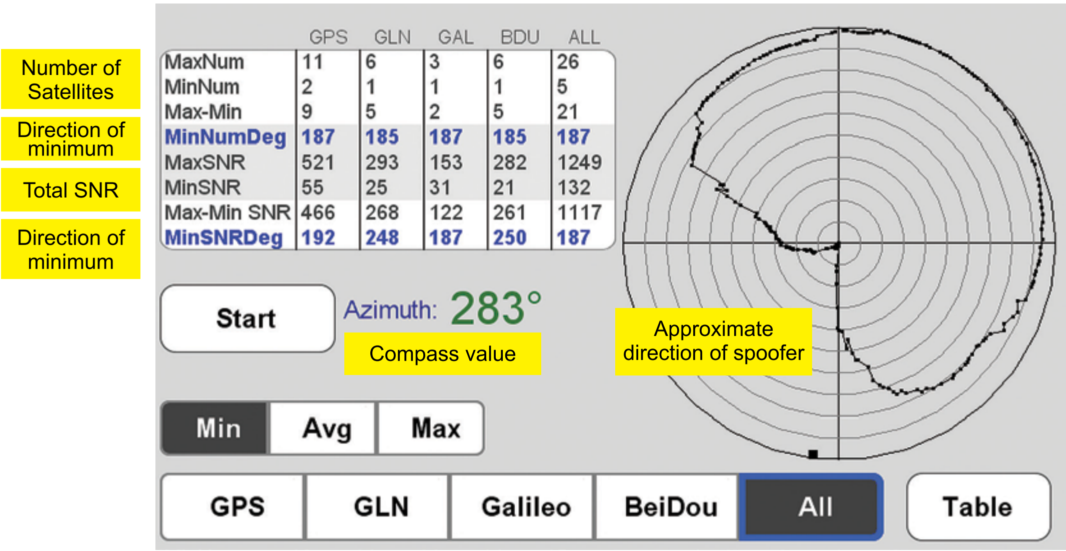
Tri-band UHF receiver with Bluetooth, USB, and internal battery. Suitable for TRIUMPH-2 Rover.

Modems

Spoofer Orientation

When you detect that spoofers exist, you can also try to find the direction that the spoofing signals are coming from. For this, hold your receiver (e.g. TRIUMPH-LS) horizontally and rotate it slowly as shown in the picture (one rotation about 30 seconds) and find the direction that the satellite energies become minimum. This is the orientation that the spoofer is behind the null point of the antenna reception pattern.

After one or more full rotations observe the resulting graph that shows approximate orientation of the spoofer as shown in figure below.



This screenshot is from the experiment within the anechoic chamber. That is why the picture is so clean.

Spoofer detection available in all of our OEM boards. www.javad.com

I am on a job now with 143 iron pins found so far. The J-Tip has been awesome for me.

I was out with another local surveyor on this same job last Saturday, and he carried his classic Schoenstedt. There were signals that his detector did not really give a definite reading on, that the J-Tip did. There was also a railroad spike 6 inch deep in the road that the J-Tip missed, and his Schoenstedt did find. When I put the J-Tip over his spot, I only had a 1.8 positive reading, which did drop back to zero when I moved away. When the spike was exposed, the J-Tip reading was 11 while in contact with the spike.

I am also getting good at judging depths before we dig in the road. I am usually within an inch.

John Evers

As for the performance, you can't beat it. However, I want to put out a kudos to the support team from Javad. My LS had a hiccup a couple weeks back. John Evers worked tirelessly into the evening trying to fix it. When it came time to send it in for repair, Michael Glutting sent me his personal LS to keep me going for the few days until the rental unit arrived. THANKS. I don't think you would see that kind of service from any vendor any where.

Bob Farley

I needed it, the LS and the J-tip found it. Another game changer from Javad.

David M. Simolo

Here is an interesting shot. I wanted to shoot the rebar, on the ground. But, post was in the way. I drove a 16d nail, with it's head cut off, (leatherman did that) and used a plumb bob to get it just right. Then, took the LS off the pole, and there is a small hole in the "handle" which I placed over the headless nail. It sat and shot it, while I did other things.
As you can see, by the tree, and shade, this is not a shot for just any GPS.

Nate

SW Arkansas, USA, Planet Earth

An IGS-based simulator of ionospheric conditions for GNSS positioning quality assessment

Currently in its first development phase, this simulator allows for a rather accurate simulation of the space weather conditions at minimum costs

Mia Flić
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Dean and Professor of International School, Beihang University of Aeronautics and Astronautics, Beijing, China

The analysis of space weather and ionospheric disturbance effects on satellite navigation, its performance and operation relies upon either the identification of the deteriorating conditions and setting up the GNSS equipment for data collection, or the utilisation of model-based simulators that hopefully resemble the natural conditions of a space weather or an ionospheric event. Here we present an alternative approach, based on the experimentally collected GNSS observations using the International GNSS Service global network of reference stations. In recent development, we have developed an IGS-based statistical learning-driven simulator of ionospheric conditions for GNSS positioning, that examines the requirements given by its user (description of a class of a space weather event with the choice of geographical region and GNSS systems/pseudoranges to be used), finds out the appropriate storm-case through the search of the internet-based archive of space weather indicators, and returns the most suitable IGS RINEX record of GNSS pseudorange observations with which a GNSS (SDR) receiver is to be fed for the space weather/ionospheric effects assessment. Currently in its first development phase, this simulator allows for a rather accurate simulation of the space weather conditions at minimum costs. Future research will be aimed at refining the algorithms for identification of the suitable space weather storm-case by expansion of the related space weather descriptive parameters and deployment of advanced artificial intelligence storm-case selection algorithm.

We have demonstrated the concept of real pseudoranges-based GNSS simulator using the IGS database and its web-interface in development of an IGS-based simulator of ionospheric conditions for GNSS positioning quality assessment.

Space weather is recognised as the single most influential natural source of GNSS positioning performance degradation. With continuously rising number of GNSS-enabled technology and socio-economic applications and services, satellite navigation has become an essential component of the national infrastructure. Risk assessment of satellite navigation utilisation in application and services development requires the ability to assess the GNSS positioning performance in different positioning environment scenarios.

Introduction of the GNSS Software-Defined Radio (SDR) receiver concept offers an invaluable research tool to scientists and engineers. In the SDR deployment, a GNSS receiver is constructed in a manner that minimises specialised hardware processing through transition towards software-based processing. The SDR concept retains the necessary specialised hardware-based signal processing in the Radio-Frequency

(RF) domain, while the processing tasks in Base-Band (BB) and Navigation Application (NA) domains are performed with dedicated software run on the general-purpose hardware (an ordinary PC or a smartphone, for instance).

The transition from hardware-specific to software-specific signal processing discloses the GNSS positioning process, rendering it suitable for evaluation and improvement through introduction of new models, processing methods and algorithms that can be easily deployed and evaluated. Research and evaluation can be conducted in the specific domain, without the requirement for utilisation of the whole GNSS positioning process. Finally, the modularity of GNSS SDR software allows for immediate assessment of the effects of new models, methods and algorithms on the over-all GNSS SDR receiver positioning performance, all those without leaving laboratory.

A GNSS SDR receiver may act as a test-bed for positioning and error correction models, methods, algorithms and applications performance validation and testing without leaving the laboratory. New research opportunities created by utilisation of the GNSS SDR concept call for an accurate and low-cost simulation of different positioning environment scenarios in laboratory. The ability to mimic various real scenarios in SDR-based environment is recognised as essential for the new generation GNSS applications development.

> The utilisation of the IGS-based GNSS simulators mitigates the effects of modelling errors that inevitably appear when the GNSS signal is artificially modelled, without any investment apart from a standard computing and internet-access equipment.

Here we address the opportunities to create real-world utilisation scenarios for the Navigation Application Domain research based on the GNSS SDR environment.

The GNSS positioning performance process in the NA domain is based on the utilisation of two sets of information: raw measured GNSS pseudoranges and information extracted from the received GNSS navigation message.

Satellite-based position estimation is a measurement-based process, thus exposed to systematic and random errors sources of both natural and artificial origin. Those unavoidable leave signatures in received GNSS signals. Signatures of the GNSS positioning environmental effects are brought with the GNSS positioning signals into a GNSS receiver, causing systematic and random errors of GNSS position estimates. The character of both kinds of errors is determined by the nature of the very positioning environment in which the GNSS signals were observed, and by the nature of the GNSS signals distortion. Distorted GNSS signal is then used in GNSS pseudorange measurement.

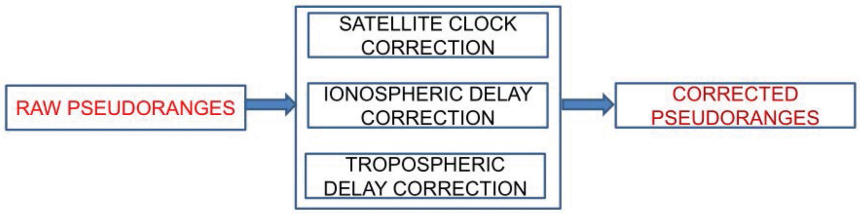
The signatures are duly transferred to NA domain in the form of the error-corrupted GNSS pseudorange observations. A GNSS receiver is designed to attempt to mitigate the systematic errors, at least. The mitigation process involves utilisation of three essential correction models, for which the real-time parameters are usually supplied in satellite navigation message: ionospheric correction model, tropospheric correction model, and satellite clock error correction model. Corrections of satellite clock, ionospheric and tropospheric errors are applied on the observed raw GNSS pseudoranges in the preparatory information process in the NA domain to mitigate known (systematic) GNSS positioning errors. Corrected GNSS pseudoranges will retain random errors, and in that form enter the GNSS position estimation procedure.

Preservation of GNSS positioning environment effects should be avoided in the GNSS positioning estimation procedure. However, it becomes essential for creation of a GNSS SDR laboratory test bed, since it emerges as a natural concept for laboratory simulation of the real GNSS positioning environment.

Two approaches emerge as candidates for GNSS positioning environment simulation development.

A traditional approach is based on the simulation of the GNSS positioning environment using complex mathematical models of that distort the GNSS signals-in-space (radio signals in RF domain), and generates the RF signal that a GNSS receiver may be fed with using the aerial interface. A traditional simulator

Figure 1 The GNSS position estimation procedure extends over three essential domains



$$\rho_r = R + \varepsilon_{syst} + \varepsilon_{rand}$$

$$\rho_c = R + \varepsilon_{rand}$$

Figure 2 A preparatory segment of Navigation Application (NA) domain

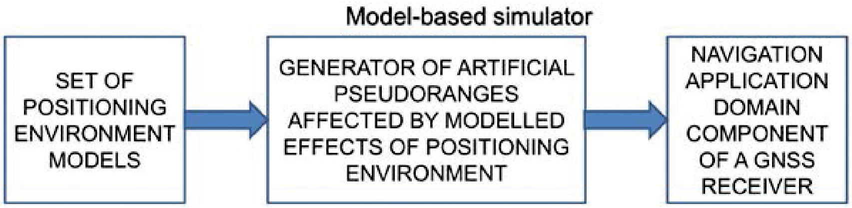


Figure 3 A traditional model-based GNSS simulator

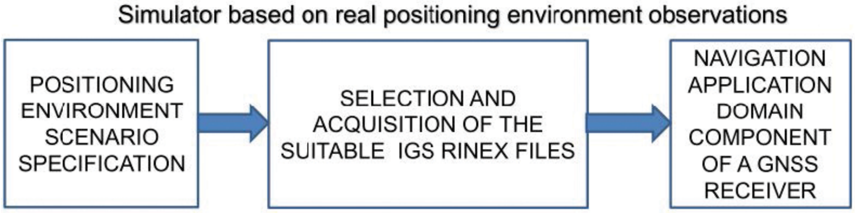


Figure 4 Proposed real observation-based GNSS simulator

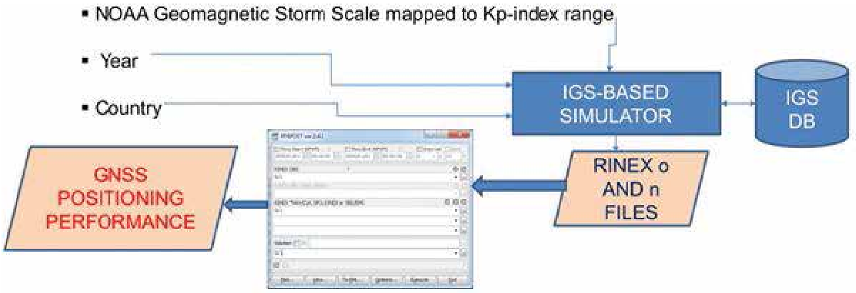


Figure 5 A proof-of-concept IGS-based ionospheric conditions simulator for GNSS positioning performance assessment

engages the complete GNSS architecture in positioning process, assuming the traditional design of a GNSS receiver based on signal processing-specific hardware. Requirements for simulation of a broad range of various scenarios render a traditional GNSS simulator a costly piece of laboratory equipment.

We propose an alternative real-observables approach that preserves the actual GNSS positioning environment conditions for processing in the NA domain, as depicted in Fig X. The approach relies on availability of a large database of GNSS pseudorange observations taken in different positioning scenarios and GNSS positioning environment conditions (space weather/ionospheric conditions, meteo-conditions, multipath environment conditions etc.). International community, that involves the UN International Committee on GNSS among the other organisations, has managed such a database for decades. Acting under the name of the International GNSS Service (IGS), it continuously collects the GNSS-related observations with 30 s separation 24 hours a day throughout the year using a systematically organised global network of stationary reference stations. Along with dual frequency GPS pseudorange observations, reference stations collect the received navigation messages. Some stations provide additional details on meteorological conditions, or pseudorange observations related to other GNSS systems (GLONASS, Beidou and Galileo). Collected GNSS-related data are available openly, in a standardised RINEX format, without licence. A user can access data using a web-based interface.

We have demonstrated the concept of real pseudoranges-based GNSS simulator using the IGS database and its web-interface in development of an IGS-based simulator of ionospheric conditions for GNSS positioning quality assessment. We established a simple ontology that allowed us to define the criteria for RINEX data files selection based on an ontological description of position environment conditions scenario.

A positioning environment scenario is specified with the space weather condition (the NOAA Geomagnetic Storm Scale mapped to Kp-index range), year of positioning environment conditions simulation, and the country in which the positioning environment is to be simulated. The IGS-based simulator we prototyped utilises a simple naïve decision tree -method to select the most suitable RINEX data for the required scenario, requests related RINEX files from the IGS database, and stores them on the local data storage for an off-line processing with laboratory GNSS SDR in the NA domain.

The utilisation of the IGS-based GNSS simulators mitigates the effects of modelling errors that inevitably appear when the GNSS signal is artificially modelled, without any investment apart from a standard computing and internet-access equipment. As the IGS provide its services mainly to scientific community and ask for the services to be used in a fair way, we limited the frequency of the IGS database access in accordance with the IGS recommendations.

Initial validation of the proof-of-concept IGS-based ionospheric conditions simulator for GNSS positioning performance assessment shows the results beyond the expectations.

Our team continue research activities on advancement of the ontology development for the GNSS positioning environment scenario description, development of the neural network-founded expert system for IGS-based GNSS positioning environment simulation, and the system expansion for provision both pseudorange-feeding (to NA domain of a GNSS SDR) and signal-feeding (to BB domain of a GNSS SDR) simulator capabilities.

Acknowledgements

This report is based on the presentation given by two leading authors at the UN/USA Workshop on International Space Weather Initiative (ISWI) held at Boston College, Boston, MA, 31 July – 4 August, 2017. MF and RF appreciate support for participation from the UN Office of Outer Space Affairs, Vienna, Austria and Boston College, Boston, MA.

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Galileo update

Ariane 5 launches four Galileo satellites in year-end Arianespace mission

Arianespace performed its eleventh and final launch of the year, sending four Galileo European navig Arianespace used an upgraded version of the Ariane 5, called "Evolution Storable" or Ariane 5 ES, modified further to support the deployment of Galileo, including enhancements for a nearly four hour long "ballistic" or non-propulsive transport phase of the mission. Only one other Ariane 5, also an ES variant, has been used for Galileo. The rest all used Soyuz rockets to launch pairs at a time.

The European Commission has one more Ariane 5 launch of another four Galileo satellites planned for July 2018 to complete the constellation, ensuring complete availability of the European GNSS.

The four new satellites all sport refurbished atomic clocks to prevent a repeat of the malfunctions on older satellites. Paul Verhoef, the European Space Agency's director of navigation, said investigations into the clock problems identified the causes, and additional corrective steps followed "in order to make sure that we keep the clocks alive as long as we can."

Though Galileo is designed to bring autonomous GNSS capabilities to Europe, the constellation is most accurate when paired with the U.S. GPS. Verhoef said the combination of GPS and Galileo "will allow an accuracy of around 30 centimeters," but declined to state the accuracy of Galileo as a standalone system.

European GNSS Agency (GSA) Galileo service program manager Rodrigo da Costa called Galileo's standalone accuracy "theoretical" because the majority of users (smartphones and other devices) will have access to several constellations.

"It's not mutually exclusive — multi-constellation and having a fully autonomous system," added Christoph Kautz, deputy head of unit, Galileo and the European Geostationary Navigation Overlay Service, EGNOS – Applications, Security, International Relations, at the European Commission. "We are following different goals. One is the strategic goal of being autonomous, and that we will achieve, and then we have also the goal to provide benefits to the user, and this we provide interoperability, for example, with GPS." *http://spacenews.com*

BeiDou soon compatible with European navigation system: official

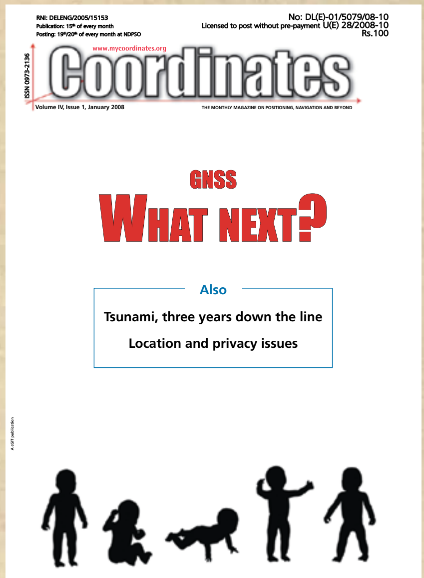
China's domestic navigation system has been gaining international recognition and use in the past five years and will integrate with Europe's Galileo satellites in the near-future, transport officials and developers have announced.

China is working to have BeiDou used by the International Civil Aviation Organization and other international systems, Peng Siyi, who is in charge of the Ministry of Transport's comprehensive planning department, said at a press conference recently.

China and the US signed a joint statement on civil signal compatibility and interoperability between BeiDou and GPS in November, according to the BeiDou website. *www.hellenicshippingnews.com*

In Coordinates

10 years before...



mycoordinates.org/vol-4-issue-01-January-08/

GNSS: What next?

It is a fascinating time for GNSS. The US is set to modernize GPS and Rissia is making steady progress on GLOSNASS. Despite the intricacies involved, Europe is determined to realize Galileo. Not surprisingly, the industry is introducing imaginative and innovative applications built around these technologies. The technology providers face the additional challence of meeting the evolving needs of the users.

Location and privacy issues

The very capabilities of geospatial tools in information analysis have raised a multitude of novel and interesting personal privacy issues

Professor George Cho
School of Resource, Environmental and Heritage Sciences, Division of Health, Design and Science, University of Canberra, Australia

Fair information practices are the cornerstone of many privacy laws today.However, these practices may be found wanting especially when they have to deal with data manipulation using disparate databases joined together in geospatial technologies such as a GIS. The solutions may lie in a mix of international standards, self-regulation, legislation, and government policy. While the harmonisation of laws and regulations and getting consistency of privacy protection especially across all jurisdictions is very difficult to achieve, yet, international standards must, of necessity, emerge.

Galileo BOC(1,1) Signal Tracking

Deok Won Lim, Chansik Park, Sang Jeong Lee
School of Electrical and Computer Engineering, Chungnam Nat'l University, South Korea

A design and implementation of GPS/ Galileo software receiver is discussed

"Everybody is committed to their task"

India has recently launched the National Tsunami Early Warning System (TEWS) established by Ministry of Earth Sciences. Coordinates discussed various aspects of the TEWS with Dr P S Goel, Secretary to the Government of India, Ministry of Earth Sciences

Improving of the EGNOS system in Algeria for dual frequency

The objective of this present work is to analyze the coverage of the EGNOS system for the civil aviation applications in Algeria. The main searched results concern the comparison between the availability of the system when using the single frequency (L1) in simple mode, and the double frequency (L1/L5)

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The European system EGNOS (European Geostationary Navigation Overlay Service) provide ranging signals transmitted by GEO satellites, differential corrections on the wide area and additional parameters aimed to guarantee the integrity of the GNSS user. EGNOS offers the following information:

- Satellite orbit and clock corrections to the existing satellite navigation services (GNSS and GEO), as well as the estimation of errors associated to satellites or User Differential Ranging Error (UDRE).
- Ionospheric corrections for a given grid of points, as well as the estimation of errors associated to ionosphere or Grid Ionospheric Vertical Error (GIVE).
- Satellite orbit/clock corrections and ionospheric corrections are dynamically modeled. EGNOS shall communicate the user the corrections that are available to be used by the receiver. The information of the models is packed on messages to be sent to the user.
- Tropospheric corrections are statically modeled, which means that corrections are tabulated and the information does not depend on any external behavior but the user position (a mean troposphere is assumed).

Aviation navigation requirements

Several Satellite Based Augmentation Systems are currently in use by the aviation community. The Federal Aviation Administration's objective in using GPS is to provide enhanced services and reduce infrastructure cost for aircraft navigation. To do so, the Required Navigation Performance (RNP) for accuracy, integrity, availability, and continuity must be met. These four parameters are defined as follows:

- Accuracy corresponds to the difference between the measured and the real position, speed or time value.
- Integrity refers to the confidence the user is able to have in the calculation of the position. Integrity includes a system's capacity to provide confidence thresholds as well as alarms in the event that anomalies occur.
- Continuity defines a system's ability to function without interruption throughout the operation the user wants to carry out (for example landing a plane). Continuity is the probability, from the moment that the accuracy and integrity criteria are fulfilled at the beginning of an operation that they continue to be fulfilled throughout that operation's entire duration.
- Availability is the percentage of time in which, over a certain zone geographical area, the accuracy integrity and continuity criteria are fulfilled. [**1**]

The requirements for the civil aviation have been standardised by the International Civil Aviation Organisation (ICAO) and they

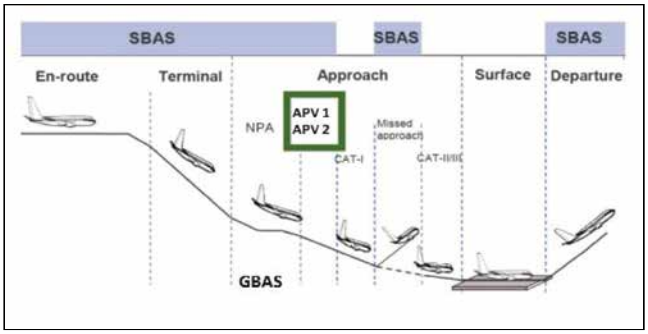

Figure 1: Evolution of aeronautic phases of flight [2]

Figure 2: EGNOS reference stations [3].

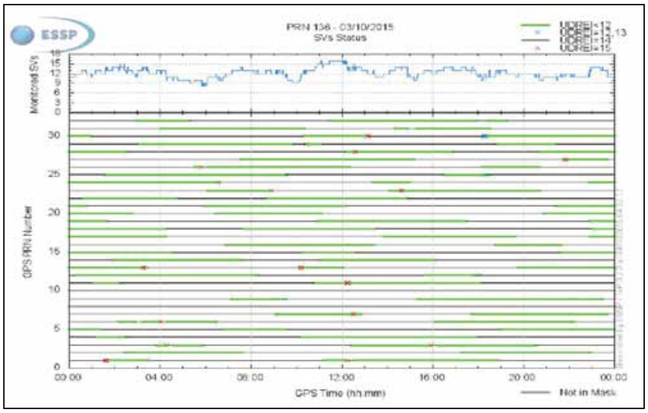

Figure 3: GPS satellites monitoring status on 03/10/2015 [3]

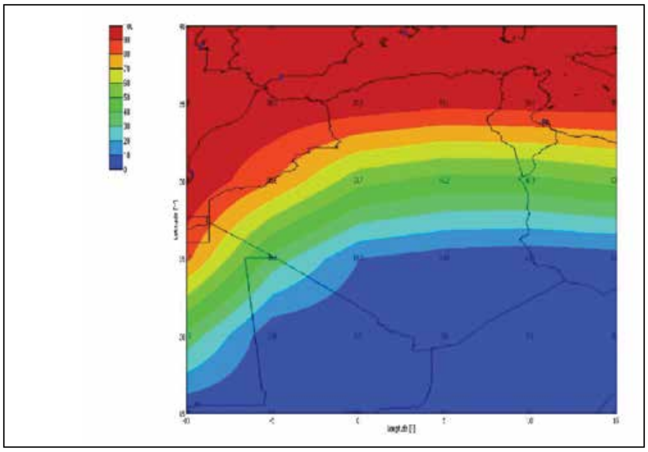

Figure 4: EGNOS horizontal availability performances with L1 frequency (HPL<HAL = 40) m) with the current RIMS network

assume different values for each specific phase of flight. ICAO for SBAS for en-route through category I precision approach operations are shown in figure 1.

EGNOS extension in the MEDA region

At present, in the mission of EGNOS, the provision of services for MEDA (MEDiterranean Area) is foreseen. This extension will improve simultaneously the performances over the core EGNOS and MEDA service areas, creating new markets in emerging countries.

The main function of the Ranging and Integrity Monitoring Station (RIMS) is to collect measurements from GPS satellites and to transmit these raw data every second to the Central Processing Facilities (CPF) of each Mission Control Centre (MCC).

The current RIMS network comprises 39 RIMS sites located over a wide geographical area. Figure 2 shows the geographical distribution of the RIMS already in operation and where no RIMS station is installed in Algeria.

Use of single-frequency

For a single frequency user, each line-of-sight has four confidence terms that are summed together to obtain the total confidence. These terms correspond to: the satellite clock and ephemeris corrections (σ_{flt}), the ionospheric correction (σ_{UIRE}), the airborne code noise / multipath (σ_{air}) and the tropospheric error (σ_{trop}).

The total one-sigma confidence bound for a particular line-of-sight is the root sum square of these four terms **[4]**:

$$\sigma_i^2 = \sigma_{i,flt}^2 + \sigma_{i,UIRE}^2 + \sigma_{i,air}^2 + \sigma_{i,tropo}^2 \quad (1)$$

Where:

- $\sigma_{i,flt}^2$ is the fast and long-term degradation confidence, which is the confidence bound on satellite clock and ephemeris corrections;
- $\sigma_{i,UIRE}^2$ is the user ionospheric range error confidence, which is the confidence bound on ionospheric delay corrections;
- $\sigma_{i,air}^2$ is the airborne receiver error confidence, which is the confidence bound on aircraft user receiver error;
- $\sigma_{i,tropo}^2$ is the tropospheric error confidence, which is the confidence bound on residual tropospheric error**. [5]**

For the single frequency mode the overall satellite residual is computed as **[6]:**

$$\sigma_{i,sf}^2 = \sigma_{i,flt}^2 + \sigma_{i,UIRE}^2 + \sigma_{i,air,sf}^2 + \sigma_{i,tropo}^2 + \sigma_{i,RIMS}^2 + \sigma_{i,system}^2 \quad (2)$$

Where:

$\sigma^2_{i,RIMS}$ is the error contribution from RIMS, and
$\sigma^2_{i,system}$ is the overall constellation system error.

Use of dual frequency

The usage of dual civilian frequencies (L1 and L5) is an attempt to address the largest delay estimation in the EGNOS system (ionospheric delay), the need for better improvement of its error estimation and correction was raised. This need lead to the potential use of both L1 and L5 frequencies together which would improve the performance for GPS users by allowing them to estimate and correct/mitigate the ionospheric errors.

This is done in a way through which the GPS dual frequency receiver would be directly involved in estimating the ionospheric delay and applying its error factor to the pseudo-range measurements for each line of sight GPS satellite without any help needed from the EGNOS system. There is another major advantage from using the dual frequency system which is its relative immunity against unintentional interference. So if one of the signal frequencies has been jammed, we will still have visual and measurements from the second signal from the same satellite**. [7]**

For an L1/L5 dual-frequency GPS/EGNOS user, the weighting matrix W is a diagonal matrix and the inverse of the i[th] diagonal element is given by the variance for the corresponding satellite, $\sigma^2_{i,dual}$ as calculated in equation:

$$\sigma^2_{i,dual} = \sigma^2_{i,flt} + \sigma^2_{i,air,L1-L5} + \sigma^2_{i,trop} \quad (3)$$

Where $\sigma^2_{i,flt}$ and $\sigma^2_{i,trop}$ are defined in the same manner as in Equation (1), and $\sigma^2_{i,air,L1-L5}$ is the L1/L5 dual-frequency airborne receiver error confidence, which is the confidence bound on ionospheric-free receiver measurements for an L1/L5 dual-frequency GPS/EGNOS user. Note: Because the calculation of $\sigma^2_{i,air,L1-L5}$ already considers both the L1/L5 dual-frequency user ionosphere range error confidence, and the airborne multipath and noise error confidence, there is no need for additional terms accounting for these errors in equation (3) [5].

For the dual frequency mode the overall satellite residual is computed as **[6]**

$$\sigma^2_{i,df} = \sigma^2_{i,DFC} + \sigma^2_{i,iono} + \sigma^2_{i,air,df} + \sigma^2_{i,tropo} + \sigma^2_{i,RIMS} + \sigma^2_{i,system} \quad (4)$$

Where:

$\sigma_{i,DFC}$ is the model variance for dual frequency residual error

Availability analysis

The criterion of this research is to compare the coverage of availabilities in Algeria versus the horizontal and vertical alert limit (HAL and VAL) under the different cases. The simulation tool used is the SBAS Simulator 2 including dual- frequency developed by European Space Agency (ESA). The following parameters were used to evaluate EGNOS system performance in flight operations:

- Date 03/10/2015; EGNOS satellite monitoring status for each satellites GPS as function of the precision indicators (UDREI) is given in figure 3.

The monitoring status of each satellite in function of UDREI, it's given by:

  - UDREI<12: SV satellite is used by EGNOS.
  - UDREI=12, 13: Although not considered as unhealthy, satellites with UDREI ≥12 cannot be used for all services.
  - UDREI=14: SV unmonitored.
  - UDREI=15: SV unhealthy.
  - The satellites that are not in EGNOS GPS mask are also represented in the figure 3.
- The area covered is [-10, 15] degree in longitude and [15, 40] degree in latitude (to allow coverage for all the Algerian country);
- RIMS Network: RIMS stations used in the simulation is based on operational stations in 2015 which are in total of 39, presented in figure 2;
- σUDRE and σDFRE is determined by the interpolation; is set the value which is based on number of RIMS that monitor a specific satellite. The model used to calculate the ionospheric error (GIVE) is based on an interpolation which depends on current RIMS stations;
- Availability simulation computes the availability for a defined service level, it calculated in relation to the percentage of time when the protection levels (HPL and VPL) are below their threshold values (set for a type of operation by the alarm limits, i.e. HAL and VAL).. In this simulation we consider three services: APV1 (HAL = 40 m, VAL = 50 m), LPV 200 (HAL = 40 m, VAL=35 m), and APV2 (HAL= 40 m and VAL=20 m).

EGNOS horizontal availability

The simulation result of horizontal availability for an L1 single-frequency is shown in Figure 4.

As can be seen, in north of Algeria (φ >35°); EGNOS is available of more than 90 %; this coverage is ensured by the European stations and neighbouring countries.

However, in dual frequency mode, the simulation results show that the availability is higher than the 99% of 40 m HAL (necessary for all horizontal service) in Algeria.

Table 1 summarized EGNOS horizontal availability with single and dual frequency for all services.

EGNOS vertical availability

Now that we have appropriate estimates for the individual error components, we can construct the dual frequency case. Here we use for the availability the calculation of VPL give by equation 4; the results are shown in table 2.

For single-frequency simulation results, the coverage of APV1, LPV 200 and APV2 in centre of Algeria (φ <30°) is less than 60 %, this coverage can be improved if a RIMS station will added in the centre of Algeria for APV1 and LPV 200 [8]; the results show that availability is more than 96 % in north of Algeria (φ >35°).

In Algeria, the coverage is slightly better with 39 stations using L1/L5 because the ionospheric delay can be directly estimated; this direct use of dual frequency will be more accurate and offer higher availability. The availability of LPV 200 service is given by figure 5.

The results show that both APV1 and LPV 200 availability is nearly 100% for dual frequency; and even APV 2 availability goes beyond 97% consequently, with dual frequency. It is not obvious that the EGNOS System with GPS alone would meet more than 97 % APV 2 availability in Algeria (VAL =20 meters), as a result to complete 99 % APV 2 availability additional RIMS is required [8]. Figure 6 shows the availability obtained with the current RIMS network for this service.

Table 1: EGNOS horizontal availability with single and dual frequency for all services with the current RIMS network

ϕ :Latitude λ :Longitude Services & Frequency		25° [0° 5°]	30° [0° 5°]	35° [0° 5°]
All services (%)	L1	[4.83 10.3]	[46.2 53.7]	[93.1 97.2]
	L1/L5	100	100	100

Table 2: EGNOS vertical availability with L1 and L1/L5 frequencies for all services with the current RIMS network

ϕ :Latitude λ :Longitude Services & Frequency		25° [0° 5°]	30° [0° 5°]	35° [0° 5°]
APV1 (%) VAL = 50 m	L1	[5.52 8.97]	[55.1 59.3]	[97.9 98.6]
	L1/L5	100	100	100
LPV 200 (%) VAL = 35 m	L1	[4.83 7.59]	[50.3 56.5]	[96.5 98.6]
	L1/L5	[99.3 100]	100	100
APV2 (%) VAL = 20 m	L1	[2.76 3.45]	[35.8 42.0]	[84.1 92.4]
	L1/L5	[97.2 97.9]	[97.2 97.9]	98.6

Comparing figure 5 and figure 6, it is evident that in the case of a single frequency, EGNOS covered the north of Algeria, this coverage is ensured by the European stations and neighbouring countries. However this availability decreases moving in the south.

Conclusion

This study evaluates the performance of dual-frequency GPS in term of EGNOS availability, which is used to determine the service coverage and includes the following cases:

- Case 1: APV1 (HAL=40 m, VAL=50 m);
- Case 2: LPV 200 (HAL=40 m, VAL=35 m);
- Case 3: APV 2 (HAL=40 m and VAL=20 m).

The new signals on L5 enhance the availability of the augmented GPS system for aviation. The nominal performance with two signals increases availability to 100% for the APV1 and LPV200 approach in Algeria.

The difference between the availability obtained with EGNOS dual frequency and single frequency is decreased for services associated with a smaller VAL.

The implementation of RIMS station in Algeria allow to receive the corrections transmitted by the EGNOS system and will benefit from the advantages offered by this system in particular in the centre and south of the country, in terms of accuracy, availability, integrity and reliability.

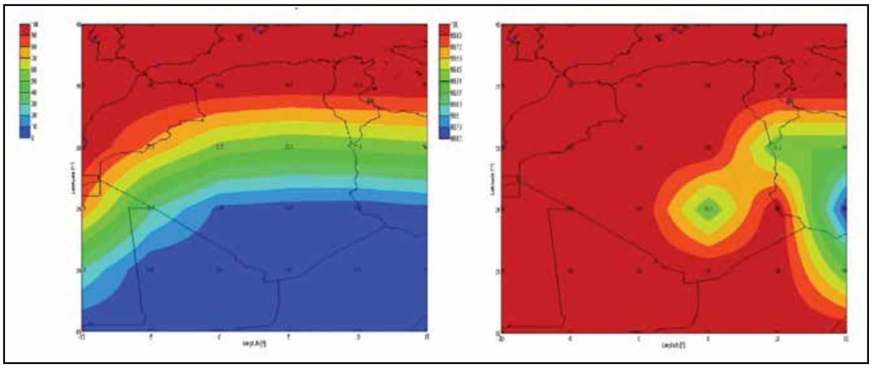

Figure 5: EGNOS vertical availability performances with L1 frequency in the left and with L1/L5 frequency in the right for LPV 200 service (HPL<HAL = 35 m) with the current RIMS network

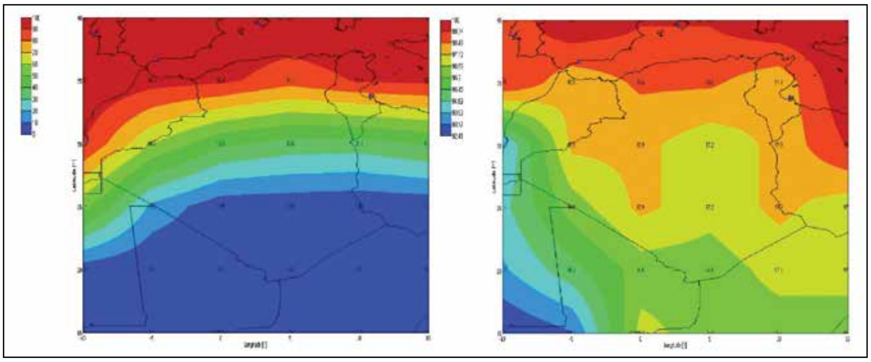

Figure 6: EGNOS vertical availability performances with L1 frequency in the left and with L1/L5 frequency in the right for APV2 service (HPL<HAL = 20 m) with the current RIMS network

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Airbus delivered GOCI-II instrument to the Korean space agency

After four months at the Korean Aerospace Research Institute (KARI) test facilities in Daejeon, South Korea, during which intensive testing was performed by a joint team of KARI and Airbus Defence and Space, the GOCI-II ocean colour imaging instrument has been delivered to the customer.

GOCI-II will be mounted on the GK2B satellite and will be launched in 2019 from Kourou on an Ariane 5. From its geostationary orbit, GOCI-II will analyse the colour of the ocean around the Korean peninsula, in order to detect, monitor, quantify and predict short-term variations in the characteristics of the coastal regions, for scientific and industrial purposes. It will acquire images of the Earth in 12 spectral bands between 380 nm and 865 nm, with resolution of about 250 m at Nadir. It will also be able to provide images of the Earth's entire disk as well as the Moon and stars for calibration. *www.airbus.com*

Airbus selected by ESA for Copernicus DIAS

Airbus has been selected by the European Space Agency (ESA) to be one of four suppliers for the Copernicus Data and Information Access Service (DIAS). It will make data and information easily available to users through a cloud computing architecture enabling enhanced coordination and cross-fertilization at European Union (EU) level and amongst initiatives at Member State or regional level.

DIAS will unify all the existing access to Sentinels products on the same "one-stop shop on the cloud" together with in-situ and third party mission data. These services will allow easy access to Copernicus data for EU citizens including the scientific community, general public and entrepreneurs who wish to process these data in order to provide their own Copernicus based services (front-offices). *www.airbus.com*

JAXA signs Implementation Arrangement with ISRO

Japan Aerospace Exploration Agency (JAXA) and Indian Space Research Organization (ISRO) signed the Implementation Arrangement (IA) concerning joint study of Lunar Polar Exploration.

JAXA and ISRO signed the Memorandum of Understanding (MOU) to promote collaboration in space field in November 2016. Under this MOU, both agencies have been exploring the possibility of mutual cooperation in the field of lunar pole surface exploration. Following the conclusion of the IA, JAXA and ISRO will jointly conduct feasibility study and draft a plan of the Joint Lunar Polar Exploration from both technical and scientific aspects. *http://global.jaxa.jp/*

Largest-ever validation of remote sensing in complex terrain

Vaisala, a global provider in environmental and industrial measurement, has collaborated with WindSim, a pioneer in computational fluid dynamics (CFD) modeling, on a study that demonstrates how the effects of complex terrain on wind measurements collected by remote sensing units can be mitigated.

According to Vaisala' new report, extensive study supported the use of Triton SoDAR data in challenging topography, paving way for more efficient wind measurement in remote regions. The collaboration has included the most extensive complex terrain validation of remote sensing data undertaken in the wind energy sector to date. The results establish a methodology for considerably reducing the uncertainty of data collected by the Triton Wind Profiler in complex terrain, opening the door to more effective measurement campaigns in areas of untapped resource.

For wind energy developers prospecting at more challenging off-grid sites (such as on ridge lines, hillsides and in heavily forested areas), the versatility, maneuverability, and size of remote sensing devices means that they offer numerous potential advantages over met towers. *www.windpowerengineering.com*

Phase One launches iX Capture 3.0 software

Phase One Industrial has released Phase One iX Capture 3.0. This capture, control and RAW conversion processing software was designed specifically for use with Phase One Industrial aerial cameras. Engineered to support easy control of all essential camera functions, iX Capture 3.0 offers a new user interface, post processing capabilities and advanced workflow to help speed the production of distortion-free RGB and CIR images, with exclusive support for processing 190MP images.

Setting up the camera is easier now with a well-organised display of essential information, including exposure settings, time interval captures, available disk space, GPS data and frame count. A new interface option enables users to choose different skins and font sizes to match the ambient lighting condition of the aircraft and to ease operation on multiple screen sizes and resolutions.

China successfully launches remote sensing satellites

China has successfully launched remote sensing satellites to conduct electromagnetic environmental probes.

The satellites were launched on a Long March-2C carrier rocket from Xichang Satellite launch center in the southwest Sichuan province, it said. They have entered its preset orbit and the launch was proclaimed a success, the report said, without disclosing the number of satellites launched. As the third batch of the Yaogan-30 project, the satellites will conduct electromagnetic environmental probes and other experiments, it added. *www.economictimes.indiatimes.com*

New satellite tracking of in-flight aircraft to improve safety

At any given time, there are approximately 59,000 aircraft in flight worldwide. The ability to effectively track, monitor and report these aircraft is paramount to ensuring the safety of passengers and crew, as well as that of communities on the ground. The United Nations specialized agency for information and communication technologies – the International Telecommunication Union (ITU) – which establishes worldwide standards that foster seamless interconnection of a vast range of communications systems, has now adopted the main technical principals of enhanced aircraft automatic dependent surveillance via satellite, to track in-flight aircraft worldwide.

Aircraft automatic dependent surveillance is a technique in which aircraft automatically provide, via a data link, data from the on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position (e.g. latitude, longitude, altitude and time) and additional data, as appropriate. The technique is termed "automatic" because there is no intervention from the pilot or interrogation from terrestrial stations, and "dependent" because the data is dependent upon on-board systems such as global positioning system and altimeter. The system relays the information to the relevant airline operators and air traffic control centers who then track the aircraft identifying any anomalies in its flight profile and initiate emergency procedures where necessary, enhancing safety in the sky.

"Since the tragic loss of life with the disappearance of flight MH370 in 2014 over the South China Sea, ITU has undertaken activities to improve the tracking of in-flight aircraft using advanced information and communication technologies," said ITU Secretary-General Houlin Zhao. "The adoption of these technical principals for enhanced aircraft surveillance via satellite will make great strides in saving lives."

Different aircraft automatic dependent surveillance systems have been standardized within the International Civil Aviation Organization (ICAO), such as terrestrial automatic dependent surveillance-broadcast (ADS-B) and automatic dependent surveillance-contract (ADS-C).

The technical principals adopted by ITU support implementation of reception of ADS-B via satellite that would enhance surveillance of aircraft, particularly in areas where terrestrial receivers cannot practically be deployed, such as in oceanic, trans-polar and remote regions – and would be a major step in the implementation of the ICAO global aeronautical distress and safety system. *www.itu.int*

Lockheed unit wins $154m deal for navigation system upgrade

Lockheed Martin Corp.'s Rotary and Mission Systems (RMS) segment recently secured a contract for providing U.S. and U.K. Trident II (D5) Strategic Weapon System Shipboard Integration Increment 8 as well as Columbia and Dreadnought efforts for the navigation subsystem. Through this contract, the company will provide the required navigation hardware and software design, testing, installation and deliverables for the shipboard integration increment. It will also deliver correlating fleet support services for the current fleet ballistic missile navigation subsystem. In particular, the contract will provide U.S. and U.K. Inertial Navigation System and gyro modification and repair, Columbia navigation subsystem development and material procurements, modernization efforts for shipboard integration program, including U.S. and U.K. trainer maintenance and development. *www.zacks.com*

GLONASS 2.0 to receive Firmware Update in 2018

The signal interface control document for GLONASS will be updated in 2018, making radio signals to the satellite navigation system less susceptible to corruption as they pass through the atmosphere, satellite producer Reshetnev Information Satellite Systems has announced.

According to the developers, the new firmware will better account for tropospheric and ionospheric refraction, drastically improving the precision of location measurements. The company says the updated control document will help reduce interference by as much as 70-80%. *https://sputniknews.com*

Russia offers UAE to use its Glonass navigation technologies

Russia is offering the United Arab Emirates (UAE) to use Russian Glonass navigation technologies, the press service of the Russian ministry of industry and trade said recently after Minister Denis Manturov's talks with Abu Dhabi Crown Prince Mohammed bin Zayed Al Nahyan.

"The crown prince agreed to think about the offer from the Navigation and Information Systems cellular operator on cooperation in the sphere of the use of Russian Glonass satellite navigation technologies in the interests of the UAE's socio-economic development," the press service said. *http://tass.com/economy/977517*

Defendants in GLONASS-M embezzlement case receive prison terms

Four men have been convicted of embezzling about 400 million rubles (about $7 million) allocated for GLONASS-M satellite vehicles, the press service of Moscow's Ostankinsky District Court has told RAPSI.

Top managers of companies Russian Space Systems and Mercury, Igor Krylov, Vitaly Tolmachev, Alexander Polyakov and Aleksey Diorditsa have been sentenced to prison terms ranging from 4 to 6 years.

As previously reported, the defendants have embezzled budget money under contracts concluded between Mercury company and Russian Space Systems for supplies of details for GLONASS-M satellites. *www.rapsinews.com*

GPS tracking as alternative to jailing migrants

Border enforcement officials are looking at using a voice-reporting system that can confirm a caller's identity and track geographical location as an alternative to jailing those who breach Canada's immigration law. Expanded electronic supervision tools such as the use of GPS electronic monitoring will be piloted in the Greater Toronto Area, said the Canada Border Services Agency, and could come as early as April.

Canada's immigration detention system has been under intense public scrutiny since 2016 after a series of deaths of detainees in immigration custody. *www.thestar.com*

Building of GPS timing backup

Senate lawmakers have introduced a bi-partisan bill giving the Department of Transportation (DoT) responsibility for launching a GPS timing backup and a two-year deadline to set it up.

Sponsored by Senators Ted Cruz, R-Texas, and Ed Markey, D-Massachusetts, the National Timing Resilience and Security Act of 2017 (S 2220) would put a stop to interagency maneuvering over which organization is stuck with developing, managing and, most importantly, paying for the new system.

The bill has been assigned to the U.S. Senate Committee on Commerce, Science, and Transportation of which both Markey and Cruz are members. Cruz has taken an interest in securing a backup, questioning Diana Furchtgott-Roth about it during the November 1 hearing on her nomination to be assistant secretary for research and technology at the DoT — a key position for position, navigation and timing (PNT) policy. Furchtgott-Roth told Cruz she would work with him on a GPS backup and on a possible public-private partnership to fund its development. Such a partnership, which has long been proposed, could help limit the financial commitment of the government and is clearly allowed by the legislation.

Coordinated drone swarm fly in tight formation — without GPS

Getting quadrotor drones to work together in swarms can lead to some spectacular, and potentially immensely useful, displays. However, in order for them to function together as a group, most drones rely on GPS or an external motion-capture system to keep them working together. That is fine in a lot of scenarios, but it is still a limiting factor that reduces where these drone swarms can be used. Researchers at the University of Pennsylvania may have a solution, however. In a step toward autonomy for flying robot swarms, they managed to teach a swarm of a dozen quadrotors to fly together in formation effectively — using nothing more than a small downward-looking camera with a 160-degree field of view and a simple inertial measurement unit (IMU.) The result is reportedly the world's biggest swarm of drones not relying on either GPS or motion capture.

"The solution is cheap and inexpensive, and the architecture we propose is scalable and extensible," Dr. Giuseppe Loianno, a research scientist on the project. "These terms are used to refer to the ease of adding additional agents to the system without sacrificing overall performance. This is the first time that perception, planning, and control are combined for autonomous navigation of multiple interchangeable aerial vehicles — up to 12 quadrotors — without relying on GPS or an external motion capture system. We have released all the hardware and software components used in this work. In the future, we want anyone being able to fly a swarm of aerial vehicles without the use of expensive motion capture systems, and in areas where GPS is not available." Each drone in the group keeps track of its precise location and then sends updates to a ground station, which sends commands back to the swarm to make them change their location. The drones themselves are not really aware (well, as far as any drone is aware) that it is in a swarm, but rather follows instructions that happen to involve large numbers of drones working together in coordination. The system makes it possible to add more drones or easily reduce the numbers without a problem. *www.digitaltrends.com*

EU frames new rules on drone registration

The European Union (EU) member states have reached a deal on the reform of the European Aviation Safety Agency (EASA), which includes Europe's first policy on drones.

Drone owners and operators in Europe will now have to register their devices if they are "dangerous" and aircraft makers have to ensure that black box recordings can be downloaded in real-time if a plane is in distress under a new reform of Europe's aviation safety agency.

Drones that have a kinetic energy of over 80 joules based on their mass and maximum speed will be characterized as "dangerous". The European Parliament had pushed for a registration threshold of 250 grams but EU governments strongly opposed it. The rules will be applicable to all drones, including those manufactured for private use. *www.livedronenews.com*

US suspects DJI might be sending sensitive data to China

DJI is an established name in the international drone market but as per US Homeland Security, DJI might be sending sensitive US data to China, as per a New York Times article.

According to a Homeland Security memo cited by the New York Times "The Chinese government is likely using information acquired from DJI systems as a way to target assets they are planning to purchase.

The memo goes on to add "DJI is particularly interested in exploiting data from two critical infrastructure sectors: U.S. railroads and utilities. DJI squarely refuted the allegations in a statement to the New York Times, saying that the report was "based on clearly false and misleading claims." "The allegations in the bulletin are so profoundly wrong as a factual matter that ICE should consider withdrawing it, or at least correcting its unsupportable assertions," the company said.

President Kovind dedicates AP fiber grid, drone project to nation

President of India Ram Nath Kovind has dedicated Andhra Pradesh (AP) Fibre Grid and drone project to the nation.

The vision of Fibre Grid project is "to establish a highly scalable network infrastructure, accessible on a nondiscriminatory basis, to provide on demand, affordable and end-to-end broadband connectivity of 15 Mbps for all households and 100 Mbps to 1 Gbps for institutions & Offices by 2018, to enable realization of the Vision of Digital AP, in partnership with the Government of India and the private sector." AP State FiberNet Limited (APSFL) is responsible for undertaking the works of AP Fibergrid , its operations and maintenance and business activities. The AP government wants to use drones for governance, administration, and for the maintenance of law and order in the state. *www.thehansindia.com*

BAE Systems' MAGMA UAV completes first flight trails

BAE Systems and the University of Manchester have successfully performed first flight trials of Magma small-scale unmanned aerial vehicle (UAV).

The Phase I trials of the UAV controlled by blown-air system form a part of an ongoing project between the two organizations and a long-term collaboration between industry, academia and the government to develop new flight control technology. Two technologies, wing circulation control and fluidic thrust vectoring, will be tested on the Magma UAV.

UAV LiDAR mapping with direct georeferencing

In an alliance formed to make small airborne LiDARs cost-effective and accurate, Applanix has developed a small, lightweight and low powered DG (Direct Georeferencing) solution and applied it to Think 3D's Stormbee multicopter, integrated with Trimble's AP15, to make it possible and deliver maximum efficiency, accuracy and performance for LiDAR surveys for any unmanned aerial vehicle. The Stormbee is a directly georeferenced UAV LiDAR solution for 3D Industrial Mapping applications, that is designed to collect survey grade spatial data in efficient way than static LiDAR. It uses 3D mapping technology including FARO's Focus 130 laser scanner, Trimble's AP15 GNSS/Inertial receiver, Applanix's POSPac UAV GNSS/Inertial Post-Processing software and Stormbee's proprietary Beeflex software for LiDAR Point Cloud Generation.

UAE's first e-platform for UAVs announced

The first unified electronic platform for UAVs and air vehicles to be used in the UAE for recreational, service and commercial purposes has been announced. The platform, called Unified Pilot System for Unmanned Aircraft Products and Systems, is a result of the UAE government's "desire to provide a civil aviation environment and a safe community for practice". It will be used to obtain unmanned aircraft information and conform to the UAE standards established by the Committee for Monitoring the Implementation of the Light Sports System.

Traders and suppliers are now required to register their products from unmanned aircraft through the platform, which will be used in accordance with the requirements and standards of the General Authority for Civil Aviation. *www.tahawultech.com*

Precise autonomous vehicle localisation and navigation

Civil Maps has announced the availability of Fingerprint Base Map, a scalable solution for precise autonomous vehicle localisation and navigation. Architected from the ground up to meet the demands of production-scale vehicle autonomy, Fingerprint Base Map allows self-driving cars to precisely determine their location in six degrees of freedom (6DoF), while evaluating the safest route to travel. This technology serves as the localisation layer in the company's HD Semantic Map

Blue Marble Geographics adds Chinese reseller

Blue Marble Geographics has announced that Beijing E-Carto Technologies Co., Ltd. has joined the growing list of partner companies reselling and supporting Blue Marble's products throughout the world. *www.bluemarblegeo.com*

Cloud based 4D Virtual reality models

Integrated design and operations consultancy for the built environment, Bryden Wood, and BIM technology innovator, 3D Repo, have launched a new platform for visualising how construction projects change over time.

Using Virtual Reality (VR) technology and 3D Repo's database driven Digital Construction Platform, the new 4D sequence visualisation tool gives users a new perspective on design and construction projects. Accessed using market leading VR headsets, such as Oculus Rift and HTC Vive, the outputs will improve collaboration between project stakeholders, facilitate decision making and allow for better communication at all stages of a project. This functionality, together with enhanced online collaboration and visualisation features, is released as a Bryden Wood digital portal powered by 3D Repo. *http://3drepo.org/*

3D laser-mapping planned to tackle flooding and track illegal waste

England's entire landscape will be mapped with lasers to tackle flooding, help conservation work and even track illegal waste dumps, the Environment Agency said.

Under plans unveiled by the government agency, aircraft equipped with laser scanners will map all 130,000 square kilometres (50,000 square miles) of the country in 3D, including rivers, fields and national parks, by 2020.

The data gathered will be used to understand flooding risk and plan flood defences, and will also be made available for free for the public and industry including archaeologists, urban planners and even gamers.

The "lidar" – light detection and ranging – technology, which measures the distance between the aeroplane and the ground to build up a picture of the terrain, can be used to detect sudden landscape changes which could indicate illegal tips.

Environment Agency chief executive Sir James Bevan said: "This ambitious project will enhance our understanding of England's unique natural features and landscape, helping us to better understand flood risk, plan effective defences and fight waste crime. *www.belfasttelegraph.co.uk*

3D Modelling software for urban Infrastructure by BRICS member countries

Researchers from Russia, China and India will soon be working together within a project to develop software for the informative 3D modelling of urban infrastructure using laser scanning technology combined with photographic images. The project recently won the BRICS STI Framework Programme, a competition for international consortia in the field of science, technology and innovation from the BRICS countries (Brazil, Russia, India, China and South Africa). The software will be useful at all stages of the urban infrastructure lifecycle, including the detection of defects, building information modelling (BIM) and carrying out renovation work.

Specialists from Peter the Great St. Petersburg Polytechnic University (SPbPU), in collaboration with the East China Normal University and the Indian Institute of Technology Roorkee, will now work to develop software for the analysis of 3D images of infrastructure objects.

Scope of open geospatial data

Open data is available from the majority of European National Mapping, Cadastral and Land Registry Authorities (NMCAs), a new survey has found. Research by the Open European Location Services (ELS)

Project reveals that 98% of respondents provide at least some of their data free of charge. Of these, 37% make all their data available under an open licence.

Whilst open data models vary, more than 85% provide view and search services, 72% enable downloads and 67% allow its re-use in products. Users include public authorities, public services, research and education as well as commercial companies.

This survey provides a snapshot of the scope of open data from official national sources across geographical Europe, said Dominik Kopczewski, policy development manager at international not-for-profit organisation, EuroGeographics which is co-ordinating the Open ELS Project.

Solution to enhance fire safety by 3D

Luminous Group, based in Newcastle, UK, has designed a new tool which they say could revolutionise the effectiveness of vital fire safety surveys. The 3D technology specialist has launched its new RIVO software using mixed reality solutions to transform asset mapping for the oil and gas, facilities management and construction industries. It utilises Microsoft's Inside Out tracking and harnesses innovative virtual and augmented reality technology and is accessed using a Microsoft HoloLens headset for the user. The 3D mapping system can be applied to enhance fire safety by drawing up critical information in real time, be it emergency evacuation points or fire routes.

Pointfuse launch point cloud software

Users of DotProduct 3D handheld scanners can now produce 3D models at the touch of button following the release this week of Pointfuse for DP. A powerful meshing solution that offers a one-button approach to converting DotProduct scan data into lightweight, intelligent 3D models, Pointfuse for DP can potentially reduce output file sizes by tenfold, dramatically improving downstream workflows including solid modeling and Virtual Reality environments. *http://pointfuse.com/*

CPCB, India likely to use LIDAR to vertically monitor air quality

A top Central Pollution Control Board (CPCB) scientist has said that the agency may consider using advanced LiDAR (Light Detection and Ranging) devices to vertically monitor the air quality of Delhi-NCR. LiDAR is a monitoring system for mapping and modelling in micro-topography, forestry, agriculture, meteorology and environmental pollution. Elastic Backscatter LiDAR and Raman LiDAR are used in monitoring air pollutants vertically.

"The CPCB and IMD had used the Elastic Backscatter LiDAR in Delhi during the 2010 Commonwealth Games and the data was utilised in 3D modelling and forecasting during the Games," he said.

Haryana, India set up GIS CELL

Haryana Government has set up a GIS Cell in the head office of the Public Health Engineering Department with technical support from the Haryana Space Application Centre (HARSAC). Apart from this, digitisation and geo-referencing of assets such as drinking water sources and Sewage Treatment Plants (STPs) has been completed in the state, and the department is now inching towards geo-referenced digital maps showing infrastructure in habitations and towns of the state. *www.dailypioneer.com*

Nepal rejects India's offer to jointly re-measure Mt Everest

Nepal has rejected India's offer to jointly re-measure the height of the world's highest peak Mount Everest following the massive earthquake in 2015 and will carry out the exercise on its own, the top official of the Himalayan nation's survey department has said.

Nepal will, however, seek help from India and China for getting crucial data for the exercise, according to Nepal's Survey Department's Director General Ganesh Bhatta.

The Survey of India, a 250-year-old institute under the DST, proposed re-measuring Mt Everest as an 'Indo-Nepal Joint Scientific Exercise' with Nepal's survey department.

"They have not responded to our proposal. Now they are saying that they are not involving either India or China. They will be re-measuring Mt Everest on their own," Major Gen Girish Kumar, the Surveyor General of India, told PTI.

Mr Bhatta said preparatory work has already begun on the project and they are gathering preliminary data crucial for this survey.

The massive earthquake has "shook" even the basic parameters of Nepal, so data from other countries will be crucial, he said.

India is being requested to provide the levelling data while China has been asked to provide the gravity data. The data will be very important to determine the height of Mt Everest, Mr Bhatta said. *www.ndtv.com*

Tesla vehicles to get a "major navigation overhaul" in 2018

Tesla is reworking its approach to in-car navigation, and will deploy a "major navigation overhaul" in "early 2018," per Tesla CEO Elon Musk, who shared the news in response to a customer inquiry on Twitter. Musk added that the rollout will only take place after current testing underway is complete, but that it will be "light-years ahead" of the current navigation offering included in Tesla vehicles.

Musk was responding to a Tesla owner who noted that in three years of vehicle ownership, he's only seen one update of the onboard maps, and even then the information pushed to the vehicle was already out of date. Musk's response suggests that Tesla is thinking far behind simple map updates with its new navigation software, and instead will be making top-to-bottom changes to how the system works overall across its vehicles.

Tesla's current navigation software doesn't differ that much from the kinds of navigation apps you'll get on mobile devices, including smartphones, but it does build-in key information like the location of Tesla chargers and Superchargers. Still, it's one of the areas users have identified as a consistent pain point. *https://techcrunch.com*

Waze becomes first navigation app to support carpool lanes

Waze has announced it is rolling out three new features in its popular crowdsourced navigation app for iOS and Android, the most notable of which is support for high occupancy vehicle lanes, also known as carpool lanes.

If you are driving with at least one passenger, or have a hybrid or electric vehicle with a special permit, Waze will now take carpool lanes on highways into consideration when determining your optional route.

If you are carpooling, the feature can enabled under Navigation > Add Toll/HOV pass within Waze's in-app settings. If you have a fuel-efficient vehicle, it can be selected as an option under Navigation > Vehicle Type.

Mapping company Here buys ATS to boost its over-the-air tech

Here, the mapping company, have announced an acquisition of Advanced Telematic Systems (ATS), a Berlin-based developer of secure over-the-air (OTA) technology, the basis for how wireless devices — including not just cars but smartphones and other hardware — get their systems updated securely — and also, these days, help feed back information to improve how those systems operate. *https://techcrunch.com*

KCZMA blacklist Anna varsity's Institute of Remote Sensing

The Kerala Coastal Zone Management Authority (KCZMA) will approach the Ministry of Environment, Forest and Climate Change to blacklist the Institute of Remote Sensing (IRS), Anna University, which prepared the Coastal Regulation Zone (CRZ) status reports for various mega projects in Kerala.

The 90th meeting of the Authority took the decision after finding that the reports prepared by the IRS in many cases were inconsistent with the ground reality and in conflict with the ones prepared by the National Centre for Earth Science Studies (NCESS).

The IRS and the NCESS were earlier approved of by the MoEF for preparing the CRZ status reports and Coastal Zone Management Plan for projects in water front areas.

An official pointed out that there were conflicts and mismatch in CRZ-related documents and Environment Impact Assessment reports of various projects prepared by the IRS and the NCESS. In some other cases, the project proponents obtained favourable CRZ status report from the IRS after the NCESS highlighted the CRZ violations.

The High Tide Line, the imaginary line from which the CRZ areas are identified in water front areas, was found erroneously drawn in some cases. The wrong HTL would provide the violator scope for encroaching upon the CRZ areas and carrying out construction in No Development Zones, said an Authority member.

The IRS authorities denied the charges levelled against them. *www.thehindu.com*

Pix4D extends drone-based imagery with machine learning techniques

Pix4D has introduced a new image classification technique as part of its Pix4Dmapper photogrammetry software. The solution uses new machine vision techniques for photogrammetry for automatically classification of drone-based point clouds.

While Pix4D software is mostly known for photogrammetry from drone-captured imagery, one of its latest mapping innovations is a software feature that automatically classifies drone-based point clouds, based on machine learning techniques. By using this feature, entire 3D point clouds are classified into individual groupings, divided into categories such as buildings, roads or vegetation.

Global UAV's survey division obtains night flight authorization

Global UAV Technologies Ltd. has announced that its survey division, Pioneer Aerial Surveys has received authorization from Transport Canada to conduct night UAV operations in every jurisdiction across Canada except Quebec, where the application is currently still being processed. The night operations are significant to Pioneer Aerial, as the geophysical survey services will not be affected by shorter daylight hours during the winter months in Canada. Pioneer Aerial is working throughout Canada during the winter as this division of Global UAV continues to grow. *www.globaluavtech.com*

Esri India rolls out 'GeoInnovation' (CHECK)

Esri India has announced GeoInnovation – A Challenge for Startupreneurs, in partnership with Department of Science and Technology (DST), Ministry of Science. It is an exciting program for entrepreneurs who are building GIS technology-enabled start-ups. The aim of the challenge is to provide the start-ups with a platform to showcase their GIS-based business ideas and build a strong network of industry experts, investors and peer group.

Aireon deployment passes midway point

Aireon have successfully launched and deployment its space-based Automatic Dependent Surveillance-Broadcast (ADS-B) payloads hosted onboard the Iridium® NEXT satellite constellation. Prior to the deployment of these 10 payloads, the Aireon system was already receiving approximately 6 billion position reports per month. The position reports produced by the system have also received additional validation testing from several successful test flights with both the Federal Aviation Administration (FAA) and NAV CANADA.

The Aireon service is hosted by the Iridium NEXT satellite constellation, which will consist of 66 low-earth orbit interconnected satellites. A total of 81 Iridium NEXT satellites are being built, all of which will have the Aireon payload onboard. Currently, 75 satellites are planned to be deployed with nine serving as on-orbit spares and the remaining six as ground spares. The constellation is planned for completion in mid-2018. *www.aireon.com*

Telenav launches embedded navigation

Telenav has announced that European automotive manufacturers Opel/Vauxhall's new infotainment system, Navi 4.0 IntelliLink, now includes Telenav's integrated navigation system. The Telenav navigation system is available in various Opel/Vauxhall models, including ADAM/VIVA, Corsa, KARL, and Zafira. The Telenav navigation system features provide a highly dynamic, relevant, useful and personalized experience for users. *www.telenav.com*

GPS III satellite receives commands from OCX ground control segment

The first advanced GPS III satellite successfully established remote connectivity and communicated with the Next Generation Operational Control System (OCX), further validating the U.S. Air Force's modernized GPS is ready to launch its first satellite. GPS III's new

L1C civil signal also will make it the first GPS satellite to be interoperable with other international global navigation satellite systems, like Galileo.

OCX will revolutionize GPS command and control and mission management capabilities. It will control all legacy and new signals, provide protection against evolving cyber threats, and reduce operation and sustainment costs through efficient software architecture, automation and performance-based logistics. OCX represents a quantum leap in capabilities over the current system, providing flexibility and adaptability to meet future GPS mission needs. *www.lockheedmartin.com/gps.*

NovAtel joins Baidu's Apollo autonomous driving ecosystem

NovAtel and its line of NovAtel SPAN GNSS+INS products designed to provide position, orientation and time as a critical component of autonomous solutions, has joined Baidu's Apollo Autonomous Driving ecosystem – Project Apollo.

Project Apollo has been initiated to provide an open, comprehensive and reliable software platform for Baidu's partners in the automotive and autonomous driving industries. Baidu Inc., the owner of China's largest search engine, announced back in 2015 that the company planned to release an autonomous vehicle that year. Since that time, Project Apollo has expanded and several partnerships have helped grow technological advances.

Swift navigation and carnegie robotics now shipping Duro

Swift Navigation and Carnegie Robotics LLC (CRL) have announced immediate availability of Duro™, an extremely rugged, low-cost, centimeter-accurate, dual-frequency RTK GNSS receiver in an easily-deployable enclosure. Swift Navigation teamed with Pittsburgh-based CRL to develop Duro, which is a ruggedized, enclosed version of Swift Navigation's flagship Piksi® Multi dual-frequency RTK GNSS receiver. *www.swiftnav.com*

Antenova's latest compact antenna boosts GNSS signals from difficult locations

Antenova Ltd, manufacturer of antennas and RF antenna modules, is launching a brand new compact, all-in-one active GNSS antenna, part number M20047-1. It operates in the 1559-1609 MHz bands, and offers designers a useful, space-saving option for small tracking devices.

It's key features are the active components, the built-in LNA and filter, which act to boost the signal to the GNSS processor in environments where there is a restricted view of the sky and line-of-sight to the horizon is difficult. With the LNA and filtering already built into the antenna, designers will not need to add them, and can save space on their PCB.

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February 2018

18th Annual International LiDAR Mapping Forum
5 - 7 February
Denver, USA
www.lidarmap.org

IGNSS2018 Symposium
6 - 9 February 2018
Sydney, Australia
www.ignss2018.unsw.edu.au

GMA: Geodesy, Mine Survey and Aerial Topography
15 – 16 February
Moscow Novotel Center, Russia
http://www.con-fig.com/?lang=eng

March 2018

Munich Satellite Navigation Summit
5 - 7 March
Munich Germany
www.munich-satellite-navigation-summit.org

EUROGEO 2018
15 - 17 March
Cologne, Germany
www.eurogeography.eu

Gi4DM 2018
18 - 21 March
Istanbul Technical University, Turkey
gi4dm2018.org

April 2018

The 7th Digital Earth Summit 2018
17-19 April
El Jadida, Morocco
http://www.desummit2018.org/

9th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing (IGRSM 2018
24-25 April 2018
Kuala Lumpur, Malaysia
https://igrsmconf18.wixsite.com/igrsm2018

International Navigation Forum Navitech 2018
24-27 April
Moscow, Russia
www.glonass-forum.ru

May 2018

Geoscience-2018
2-4 May
Rome, Italy
http://geoscience.madridge.com/index.php

12th Annual Baška GNSS Conference
6 - 9 May
Baška, Croatia
www.rin.org.uk

FIG Congress 2018
6 - 11 May
Istanbul, Turkey
www.fig.net/fig2018/

The European Navigation Conference 2018
14 - 17 May
Gothenburg, Sweden
www.enc2018.eu

GEO Business 2018
22 - 23 May
London, UK
http://geobusinessshow.com

June 2018

HxGN LIVE 2018
12-15 June
as Vegas, USA
http://hxgnlive.com

7th International Conference on Cartography & GIS
18-23 June
Sozopol, Bulgaria
www.iccgis2018.cartography-gis.com

July 2018

GI Forum 2018
3 - 6 July
Salzburg, Austria
www.gi-forum.org

Esri International User Conference 2018
9 - 13 July
San Diego, USA
www.esri.com/events

September 2018

Inter Drone 2018
5 - 7 September
Las Vegas, USA
www.interdrone.com

ION GNSS+ 2018
24 - 28 September
Miami, USA
www.ion.org

October 2018

Joint Geo Delft Conference

The 6th International FIG 3D Cadastre Workshop

The 3D GeoInfo Conference
1- 5 October
Delft, the Netherlands
www.tudelft.nl/geodelft2018

Intergeo 2018
17 - 18 October
Frankfurt, Germany
www.intergeo.de

December 2018

The 16th IAIN World Congress 2018
28 November - 1 December
Chiba, Japan
https://iain2018.org

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